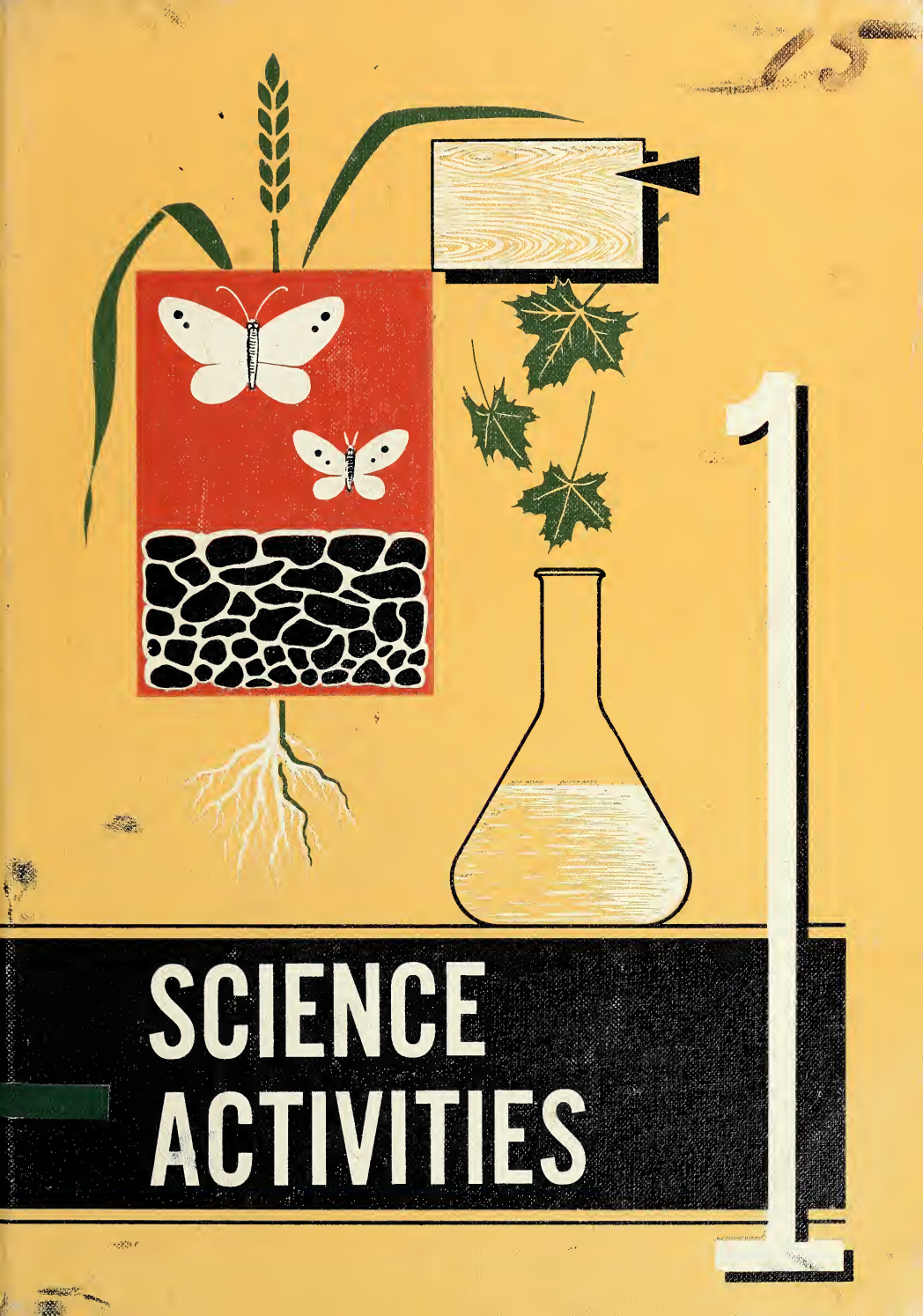
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*Drawings by* ROBERT KUNZ

D. KUNZ

# Science Activities 1

T. W. Hunt
*Superintendent of High Schools, Regina*

H. C. Andrews
*Principal, Saskatchewan Teachers College, Regina*

H. G. Hedges
*Science Master, Toronto Teachers' College, Toronto*

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# Preface

Because science touches modern life in so many ways, activities related to science should have an important place in school curricula. But whether science activities are effective or not, depends on the teaching methods employed. In preparing the two-book series *Science Activities*, the authors have kept constantly before them the importance of making science interesting and vital to boys and girls.

Each of the books is built around a central theme, which gives continuity to the content. *Science Activities, Book One* develops the theme: *Man makes use of science to help him to use and to change his natural environment to satisfy his basic needs through the study and use of plants, rocks, minerals, soil, water, and forests.* The theme of Book Two is: *Science has contributed greatly toward man's ability to live and work with others.* Book Two studies the application of science in such areas as the improvement of domestic animals, navigation, communication, uses of electrical energy, weather forecasting, and conservation.

Science involves two aspects: *useful content* (what to learn) and *scientific method and attitudes* (how to think). Throughout the *Science Activities* texts, both aspects have been kept in mind and emphasized in the selection of material and methods of presentation.

Each topic is approached through problems and activities that encourage pupils to launch out for themselves and to gather information by investigating, observing, experimenting, and reading. The books then present subject matter to supplement and support what the pupils have learned as a result of their work and thinking.

A seasonal approach (fall, winter, and spring) has been followed so that (*a*) materials for study are available, and (*b*) appropriate activities and observations can be carried on, at the time each section is likely to be undertaken.

At suitable intervals in each chapter are questions and exercises designed to focus attention on the general theme of the book, and to test the pupils' knowledge and understanding as well as their progress in the use of the scientific method and in the development of scientific attitudes.

Each chapter concludes with a test that will serve as a review of what has been learned, and in addition will test the pupils' ability to apply their knowledge in specific situations.

The text provides science experiences suitable for the majority of the pupils in each class, and includes, as well, problems and activities for pupils with special interests and abilities.

In view of the great importance of rock and mineral resources in our country, a unit on elementary geology has been included in this book.

Throughout the series, conservation has been stressed wherever applicable. In keeping with the general theme, a study is made of the causes of depletion and of practical methods of conserving many of our natural resources.

The organization and philosophy of the *Science Activities* texts are explained to the pupils in the introductory chapter of each book.

— T. W. H.
— H. C. A.
— H. G. H.

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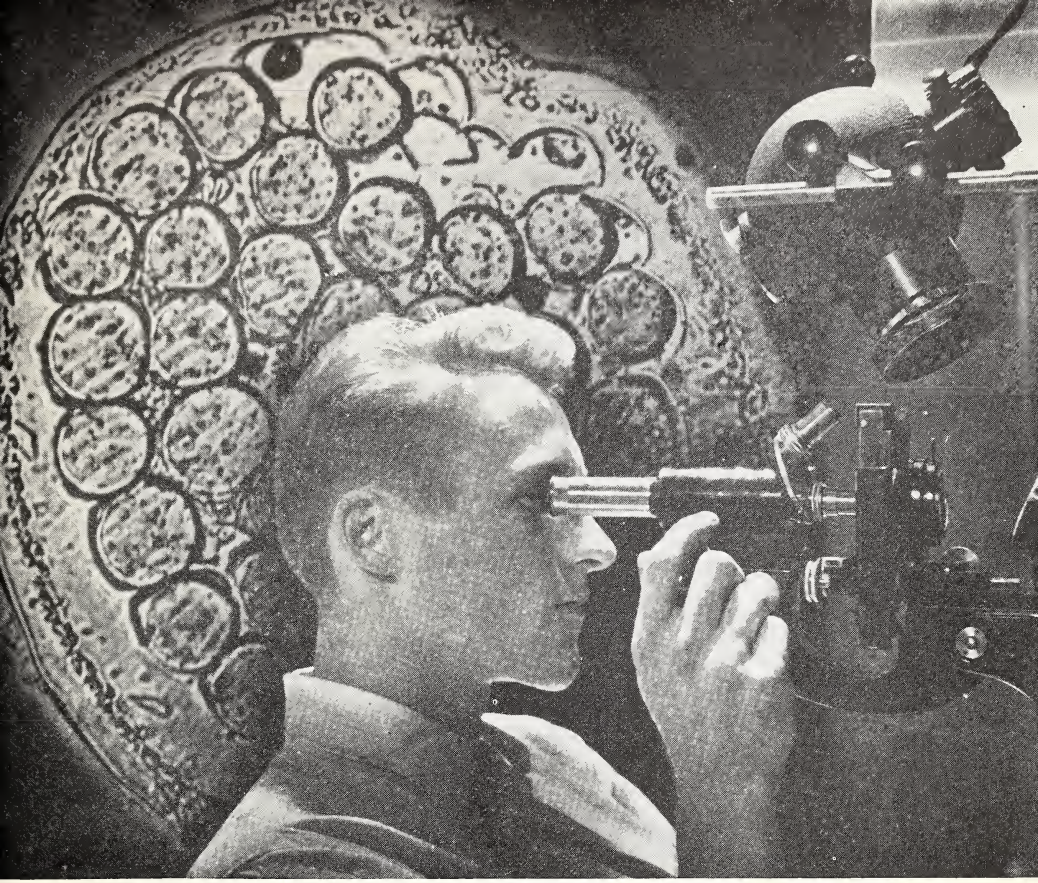


Malak, by courtesy of Du Pont Company of Canada Limited

*The scientific method is only about four hundred years old, but it has already produced more facts and inventions than did all the previous four hundred thousand years of human progress. What the present scientific facts have done for the world, we see; what the scientific method will do for the future staggers the imagination.*

*—Philip B. Sharpe*

# MAKING A GOOD BEGINNING

**Science is important to you. Why? What contributions has science made to your life? How, for instance, have scientists helped to provide you with food and clothing, with warm, comfortable homes, with safe and clean water? How have they made it possible for you to know about interesting things that have happened and are happening in the world today?**

Gordon Wayne lived with his parents on a farm near which a river wound back and forth across the land.

Usually, as fall approached each year, Mr. Wayne had a crop of wheat to harvest and sell. In their farm pasture, cattle would be grazing, and there would therefore be meat and milk for the family, and animals for the market.

Some years, however, when the rainfall was insufficient to provide the needed moisture, the crops and the pasture were uncertain.

One day there was great excitement in the locality in which the Waynes lived. News had come that a dam was to be built across the river to hold the water back. The building of such a dam would mean that some of the valleys and meadows which Gordon knew would disappear. They would become the bottom of a lake that would form behind the dam.

In the water flowing over the dam would be power to operate generators to produce electricity for light and power on nearby farms and in a distant city. From the lake, water would be carried by canals and ditches to the fields and gardens of the area to provide moisture for the crops in dry years. Gordon was thrilled to think that later there might be fish in the lake and that perhaps he could have a boat.

Since earliest times, man has used his environment (surroundings) to provide himself with food, clothing, and shelter. He has also modified or changed his environment to make it better serve his purposes. Mr. Wayne's farm is an example of the way in which we have used our natural environment (air, soil, water, forests,

rocks, etc.). The dam that was to be built across the river illustrates how we make changes in our surroundings

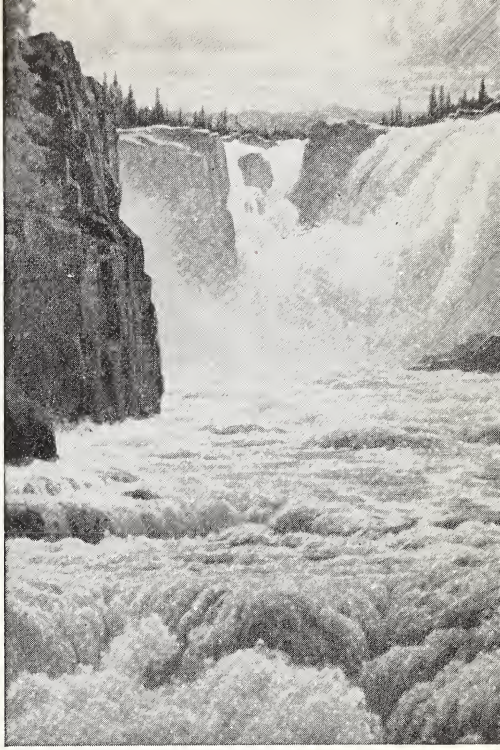
**HOW TO USE THIS PART OF THE BOOK**

This introductory section of *Science Activities* is not to be studied intensively as a unit of subject matter.

However, it includes many important ideas. Read it carefully. Discuss it with your classmates thoughtfully but briefly.

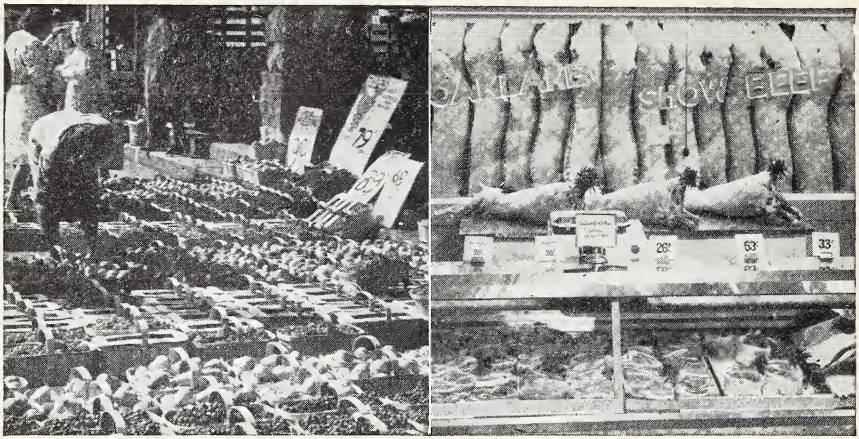
Begin now to make use of the ideas presented. We shall be referring back to many of them as we proceed through the book.

In the meantime, *be sure to take advantage of the warm days of September to study how plants live* (Chapter 1).



A safe, clean supply of water is a basic need for life itself. (Canadian General Electric Co. photo)

This farm pond, formed by building a dam across a river, is an example of how man can change his environment to satisfy a basic need. The pond will store water that can be used for many purposes. (Ontario Department of Planning and Development photo)



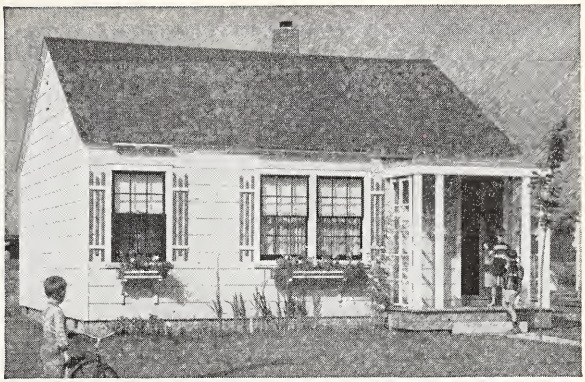
Good food, provided by plants and animals, supplies to our bodies their basic need for energy and heat. (Top left photo, National Film Board; top right photo, T. Eaton Co.)

Suitable winter clothing helps to supply our basic need for warmth. (National Film Board photo)

so that they will provide us with the things we need from day to day.

Regardless of where you live, there are certain *basic needs* for which provision must be made if you are to remain alive. You must have food to provide your body with heat, energy, and materials for growth and repair. You must have a safe, clean supply of water for drinking and many other purposes. You must have clothing, shelter, and warmth.

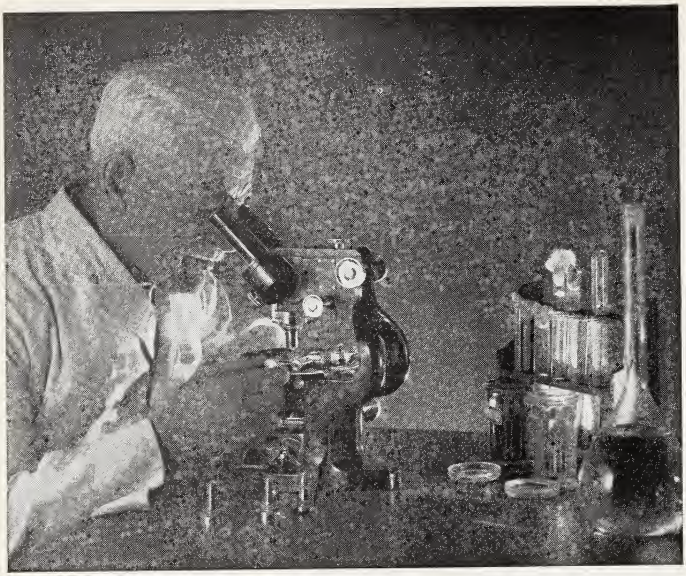
Think back over the things that happen to you on an ordinary weekday. You wake up to hear your mother or father telling you it is time to get up. Outside it is still dark; but you simply push a button in your wall, and your room is flooded with light. Hundreds of years ago boys and girls had to dress by the dim light of candles, but since that time Michael Faraday and many other scientists have performed countless painstaking experiments and made innumerable



Attractive homes not only provide for our basic needs of shelter and warmth, but also add greatly to our pleasure in living. (National Film Board photo)

Fifty years ago, the kitchen served many purposes. What activity is being carried on in this one? Notice the coal stove, wood box, wash boiler, wooden tub, wash board, wringer, pump, lanterns, and oil lamps. Compare this kitchen with the one in your home. Compare the kettle, stove, and washing equipment with the three illustrations below.

Look around your schoolroom and your home. What ways can you find in which scientists and inventors have added to the comfort, convenience, and safety of modern living? (International Nickel Co. of Canada drawing; Canadian Westinghouse Co. photos)



This scientist is using a powerful microscope that is capable of magnifying an object several thousand times. With the aid of such instruments, scientists have made many important discoveries affecting our health and our means of providing for our basic needs. (Bausch & Lomb Co. photo)

important discoveries. Now we know how to put electricity to work, and as a result, your house is bright on cold mornings when it is still like night out-of-doors. Quite likely when you go down to breakfast and pour yourself a glass of milk, you can be sure that there are no harmful germs in it, because the famous French scientist Louis Pasteur taught people how to kill harmful germs in milk by pasteurizing it. Because of the patient work of other scientists, you can turn on the radio or television set and hear the latest news, or telephone a friend to make plans for the day, or ride to school in a bus. The food you eat, the house you live in, and the clothes you wear have been developed after years of careful scientific experimenting.

Scientists are still making new discoveries, and there is still much to be learned. Every science problem that is solved helps human beings to live and work better and more wisely. In 1954, an epidemic of 15B rust, a plant disease affecting wheat, swept across the Prairie Provinces. It was estimated that the damage amounted to over $100,000,000.00. What caused the epidemic? How could it be prevented another year? Plant scientists had been working on this problem for some years. They had produced a new wheat, called Selkirk, which was immune to 15B rust. But in 1954 there was not sufficient Selkirk wheat seed for all the farmers — it had to be multiplied so that all farmers could have rust-resistant wheat to sow.

Further, the scientists knew that other races of rust existed that might attack even the good Selkirk wheat. The rust problem has not yet been solved. What will be the value of continuing, by means of scientific methods, to work for a solution?

You have already thought of many inventions that have made your life simpler and happier. These are a result of the solving of some scientific problems. But there are many problems that nobody has as yet been able to solve, and some things that have been explained only in part. Any boy or girl interested in science who learns to think and work scientifically may have the privilege some day of helping to find solutions to science problems that will make life simpler and happier for the people who live after him. There are many great examples for you to follow. The stories you will read on the next few pages tell about the lives of two men whose scientific way of living and thinking and working led them to great achievements.

### The story of Leeuwenhoek

Scientific studies would have been extremely difficult without the microscope. Today's scientist, using a modern, high-powered microscope, owes much to the work of Anthony Van Leeuwenhoek (lā′ven-hōōk).

Leeuwenhoek was born at Delft in Holland in the year 1632. As a young man he developed the hobby of grinding glass lenses or magnifying glasses which made things look larger than they really were. He became the best lens-grinder of his day. By using several of his lenses together, he made a microscope that was better than any other magnifier in existence.

Leeuwenhoek was filled with curiosity, an important scientific attitude. Through his new microscope he examined everything he could find. He looked at spider webs, bee stings, and hairs of animals, and was amazed at what he saw. One day he put a small live fish into a narrow tube of water, and looked at its tail through his microscope. He saw the fine branches of the arteries and the veins. And then he saw something else, something he did not expect to see. There were fine, hair-like vessels connecting the veins and arteries. We call them *capillaries*. Nobody had ever known that capillaries existed. By finding them, with the aid of his microscope, Leeuwenhoek had made an important discovery about the circulation of the blood — a discovery that meant much to the development of medical science.

But Leeuwenhoek's greatest thrill came when he discovered a new world — the world of microbes. One day he scooped up some water from a puddle and focused his microscope on it. He was astonished to see that the water was teeming with life. There were little animals, or "beasties" as he called them, swimming, rolling, and playing about in the water. They were so small that a hundred of them laid side by side would not reach across the head of a pin.

Leeuwenhoek at work in his laboratory, where he discovered microbes. He used a simple microscope that he made for himself. Compare Leeuwenhoek's simple microscope, which he is holding in his hand, with the modern one illustrated on page 6. (Bausch & Lomb Co. photo)

There were many one-celled plants too. These tiny animals and plants are known as *microbes.* Leeuwenhoek's curiosity was greater than ever. He looked for microbes everywhere, and almost everywhere he found them. He tried to find out more about microbes by experimenting. In material he scraped from between his teeth, he saw hundreds of microbes in various sizes and shapes. But when he examined material from the same source again, after drinking a cup of hot coffee, he could not find a single microbe in it. Further experimenting proved that extreme heat kills the "little beasties."

Other scientists followed up the work of Leeuwenhoek and discovered that some microbes are among man's best friends, and some — disease bacteria, for example — are his worst enemies. It was Leeuwenhoek, however, with his improved microscope, who opened the door into the fascinating study of the amazing world of microbes. Exploration in that world has revealed the

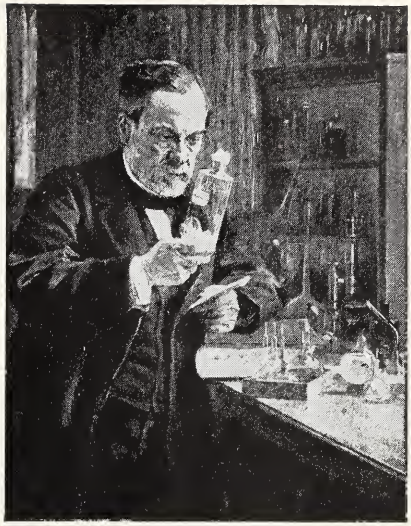
causes and led to the conquest of many diseases. It has led also to discoveries that have helped us to preserve many kinds of food and to provide ourselves with safe, clean water.

### The great scientist, Louis Pasteur

The great French scientist, Louis Pasteur, discovered many things of importance in the world today. Among his greatest triumphs were those in the control of disease. He was the first to learn that many diseases are caused by microbes or germs.

In Pasteur's time (approximately 100 years ago) a disease known as splenic fever or anthrax was killing a great many cattle and sheep in France and other parts of Europe. Pasteur began to experiment and discovered a method of vaccinating animals. He was convinced that animals could be kept free of the disease by injecting into them weakened splenic fever germs he had produced in his laboratory. However, most people, including many leading scientists of that time, did not believe that such a thing was possible. They had to be shown in the experimental way. Pasteur agreed to put his theory to the test in the presence of scientists, government officials, and others.

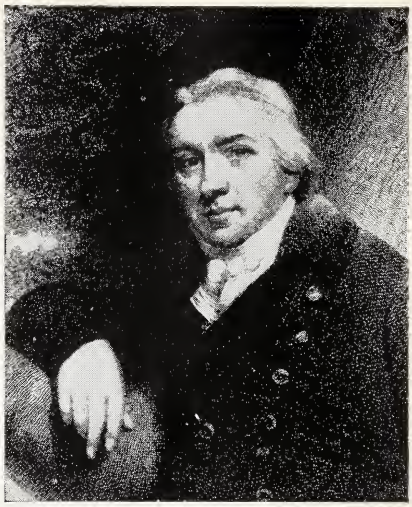
Fifty healthy sheep were selected for the demonstration. Twenty-five were vaccinated, by injecting weakened splenic fever germs under the skin. The rest were not so treated. Twelve days later the vaccinated animals were again vaccinated. Two weeks later, all fifty sheep were injected with the blood of a sheep that had died of splenic fever and whose blood, according to Pasteur, contained splenic fever germs. In four days, not one of the unvaccinated sheep remained alive, but all the vaccinated sheep were alive and thriving. The bodies of the dead sheep were opened, and splenic fever germs were found to be present.



Louis Pasteur, born of peasant parents on December 27, 1822, in a little village in France, dedicated his life to the solving of important scientific problems. (Ewing Galloway photo)

Pasteur has many other discoveries to his credit. He discovered the cause of fermentation of wine and showed how to keep wine from spoiling. After six years of study and experiment, he saved France's silkworm industry by controlling the plague that was

Healthy fruit trees, producing flowers like these apple blossoms, are protected against plant diseases and insect pests by scientifically-prepared chemicals. (Canadian Industries, Ltd. photo)



By discovering how to protect people from smallpox by vaccination, Dr. Edward Jenner (1749-1823) saved the lives of millions of people. (Metropolitan Life Insurance Co. photo)

destroying the worms. He discovered a means of preventing a person bitten by a mad dog from developing the deadly disease called rabies or hydrophobia. One of Pasteur's greatest contributions was the development of the process for making milk safe, which we now know as *pasteurization.*

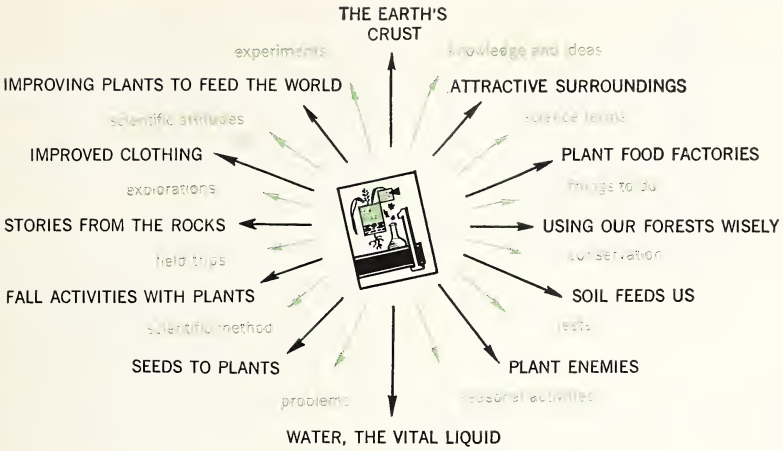
Measured by the magnitude of the service he rendered to his fellowmen, Pasteur will always rank as one of the world's great men.

### How to get the most out of your science textbook

1. *Science Activities, Book One* has been carefully organized and written to help you to gather information and to understand the very important idea that *with the help of science, man has learned to use and to change his natural environment to satisfy his basic needs of food and water, warmth, clothing, and shelter.*

If you will read the text thoughtfully and carry out a number of the activities suggested, you will add greatly to your knowledge of your environment and you will learn how we are using and changing it. There is a very great deal to know, and scientists are continually making new discoveries.

The diagram on page 11 will give you some idea of the topics that will be discussed as you proceed from chapter to chapter.




Examine carefully the illustration above. This diagram will help you to understand and to make the best use of your science text. The black labels outline the content or information in the various chapters. The colored labels tell you of the numerous activities and ideas that are described and developed.

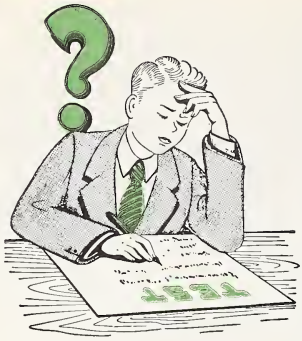
2. But science is more than a knowledge of subject matter. It is a *way of working* and *a way of thinking*. As you progress through your science book, there will be many opportunities for you to become familiar with, and to practise, *the scientific method* and to develop *scientific attitudes*.

These attitudes and methods cannot be learned by merely reading about them. It would be a waste of time to try to memorize them. They can be learned only *by doing* — by using and practising them day by day.

The various topics in the book are introduced by suggesting several things to do — problems to solve, investigations to carry out, experiments to try, first-hand observations to make, reading to undertake, class discussions to hold, and so on.

Be sure to do at least some of the things that are suggested. Be sure also that you gather as much information as you can about each topic before reading on in the book to the factual information presented. In this way, you will be practising the scientific method of solving problems. You will find, too, that you will enjoy your studies more, and will understand and remember science ideas better, when you have investigated some of the problems on your own and solved as many of them as possible for yourself.

Reviews and Tests. — There had been a lively discussion in Miss Peterson's Grade VII and VIII class about tests. Some of the pupils thought that



there were far too many of them. One boy wanted to know, "What good are they, anyway?" Then Tom Grant spoke up, "I like tests. They give you a chance to show what you know." Jim Allison supported Tom. "Not only that," he said, "but tests show you what you don't know — where there are gaps in your knowledge of a subject." "And further," added Helen Smith, "tests show you where you made mistakes in your work and how you can do better next time."

"Yes," agreed Miss Peterson, "tests can be very useful. Much depends on the nature of the tests. If we work together to plan tests that do more than just show how much we have memorized, we shall have a testing program that will help us greatly in our science activities." The pupils agreed to work with this in view.

Throughout the book, you will find many ways of testing how much progress you are making in adding to your knowledge, in finding the main and most important ideas in the topics you are studying, and in developing skill in using the scientific method to solve problems. Use the tests and activities outlined to determine how well you are doing, where you may be making mistakes, and how you can improve as your science work proceeds.

### The scientific attitude

An *attitude* is a way of behaving or thinking. A person who follows the scientific method in reaching conclusions develops a scientific attitude.

The following are the qualities of a person who has the scientific attitude:

1. The person who has a scientific attitude is full of the spirit of discovery.

A curious, inquiring person notices the things about him and wonders about the *why* and the *how* of them. Curiosity and inquiry are the very foundation of all learning. If you have ever watched a baby as he grows up, you will realize this. When he is born, he knows nothing about the world. But he is curious, and he learns quickly. He examines his hands

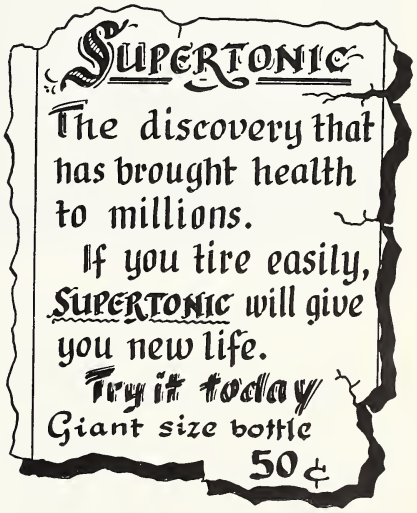
and feet; he feels his toys and tries to put them into his mouth; he watches his ball roll; he listens to the sound of his rattle or the clank of his spoon on his plate; he learns to distinguish some objects by their odor. By the time he is a year old, a baby has learned many things about his environment by using his senses: by touching, tasting, seeing, hearing, and smelling things. As soon as he learns to talk, he begins to ask questions about things. Why is this? How did it happen? What is that? The child who continues to be curious — to want to find things out for himself — is well started on the road to learning.

Curiosity is the starting point of all science and all advancement. Leeuwenhoek, looking at water through his microscope, saw the microbes moving and asked himself what they were; as a result, men found that many diseases could be prevented by destroying certain of these microbes.

Human progress, in large measure, has been dependent on man's curiosity — his desire to know.

2. The person who has a scientific attitude *finds out as many facts as he can and bases his thinking and decisions on facts.* He does not jump to hasty conclusions.

No wise person is satisfied with guesswork or hearsay. For example, when a cunning advertiser claims that a certain medicine is superior to any other and can work marvels, the unthinking man takes his word for it. But the man with the scientific attitude will not believe extravagant claims without checking them. He will insist on knowing the facts of the case: what the medicine is made of;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Try it today
Giant size bottle
50¢

how it is prepared; in what way it corrects the ailments the advertiser mentions. The man who jumps to conclusions may waste his money on a useless article, or even injure his health with the medicine; but the man with a scientific attitude will not buy the medicine unless the facts have convinced him that it will be beneficial to him.

3. The person with a scientific attitude is *open-minded. He is willing to change his opinion when confronted with new facts about a question. He desires the truth regardless of personal opinion or prejudice.*

Lou Baker had several warts on his hands. He had been told that toads cause warts; and because he believed it, he loathed them and would not touch one. His class studied toads, and learned that they are very beneficial because they eat large numbers of harmful insects. Superstitious people have the foolish idea that they cause warts, because of the warty appearance of a toad's skin, but the class proved that this idea is false. Lou Baker no longer loathed toads. He even learned to watch them at work in the garden, and became very interested in them. He showed a scientific attitude in changing his opinion of toads to agree with the facts.

4. The person who has a scientific attitude *knows that all occurrences are governed by natural laws. He knows that for everything that happens, there is a cause.*

In the following story of an occurrence, two explanations are suggested. Which is the more scientific?

Roger Forbes was walking along the street when a black cat crossed in front of him. At the next intersection he stubbed his toe on the curb and fell, breaking his glasses. He may account for his accident in two ways: (1) He may say that it happened because bad luck was bound to come after a black cat had crossed his path: (2) He may recall the fact that at the corner he did not raise his foot high enough to clear the curb, and therefore fell, thus causing his glasses to strike the hard pavement and break. With the facts of the case clearly in his mind, he may reason that the accident was the result of a definite cause. Meeting a black cat is

These boys have been experimenting. Now they are *reading* (1) to check what they have found out, and (2) to secure more information from their books. (Bruce Pendlebury photo)

not always followed by a fall. Failing to clear an obstacle (the curb, in this case) is *always* followed by a stumble or a fall. Therefore the cause of the fall was his careless step at the curb, not the meeting with the black cat.

If Roger were to accept the first explanation, he would be jumping to conclusions; he would be taking a superstitious attitude. If he were to accept the second explanation, which was reached by examining the facts and using a knowledge of natural laws, he would have a scientific attitude. A person with a scientific attitude knows that superstitions are foolish. He does not believe in wearing good-luck charms. He knows that breaking a mirror, or walking under a ladder, or the number thirteen does not bring bad luck. Whatever happens, pleasant or unpleasant, happens as a result of a natural cause.

To SUM UP.—If you have a scientific attitude, you are curious, full of a spirit of inquiry. You base your thinking and your decisions on facts. You are open-minded. You try to find the explanation of occurrences by applying natural laws.

### How can you increase your knowledge of science?

Four methods are suggested by which you can increase your knowledge of science.

### 1. Learn by trying things out for yourself

When Lou Baker was afraid that toads would give him warts, he and his classmates performed an experiment. They constructed a terrarium and kept a toad in it for a while. They picked up their pet from time to time, and learned by thus trying it out for themselves that toads do not cause warts.

You can increase your knowledge of science by constantly practising the scientific attitudes, by watching for scientific problems, and by solving them by the scientific method. It is often possible, you remember, to perform an experiment as part of the scientific method. Pasteur, the Wright brothers, Faraday, Edison, and many other great men gathered important information by experimenting. In the course of your discoveries, you too should learn the art of planning experiments carefully and performing them accurately.

### 2. Learn by seeing things for yourself

Oliver Sereda and Ben Olson wished to know more about the harmful effects of water erosion (washing away of the soil by running water). They went out in the fields during and just after heavy rainfalls. They saw for themselves what was happening. In this way they had a much better understanding of the problem involved. Further, they not only learned a great deal, but also they improved their ability to make worthwhile first-hand observations.

Curiosity is the basis of the scientific attitude, and observation is the beginning of all knowledge. It is very fine to read, for example, about our wild flowers in a good magazine or book. It is much better, however, to go out into the great out-of-doors and observe and study these flowers where they grow.

A tour of a creamery to see milk being tested, pasteurized, and bottled, or butter being churned and packed, will give you much up-to-date information about the way these important foods are handled to safeguard our health. A boy or girl who has always lived in the city can learn a great deal about ways in which food and materials for clothing are produced, by visiting a farm. The boy or girl from the farm likewise can learn how food and other farm products are processed by visiting a textile mill, a dairy, or a factory in a city, where there are many opportunities for observing scientific inventions.

Fortunate indeed is the boy or girl who has had an opportunity to travel and to see such wonderful sights of nature as mountains, rivers, lakes, oceans, waterfalls, canyons, forests, and fruit orchards. But his companion who stays at home is not less fortunate, if he has eyes that see and a mind that understands, for many of the most interesting things in nature can be found in his own back yard. Let us, then, keep our eyes wide open and our ears tuned to nature, lest we should miss some of the best things in life.

### 3. Learn by reading

It is impossible for you to repeat all the experiments that scientists have performed, or to solve all problems. Even though you long to do so, you cannot possibly explore all parts of the world from the depths of the ocean to the mountain peaks, to observe at first hand the many wonders of nature. Therefore, you will have to depend on reading for much of your information about science. Scientific magazines and books open a wide world to you. New discoveries are continually being made. Scientists are finding new and better methods of using the forces and materials of nature. Stories about them may be found in newspapers and magazines from week to week. You should be on the alert for such up-to-date information.

### 4. Learn by asking someone who knows

During their field trips to study soil erosion, Oliver and Ben saw several things that they could not understand; so they questioned Mr. Fletcher who had been very successful in preventing erosion on his farm. He answered their questions and gave them much useful and important information.

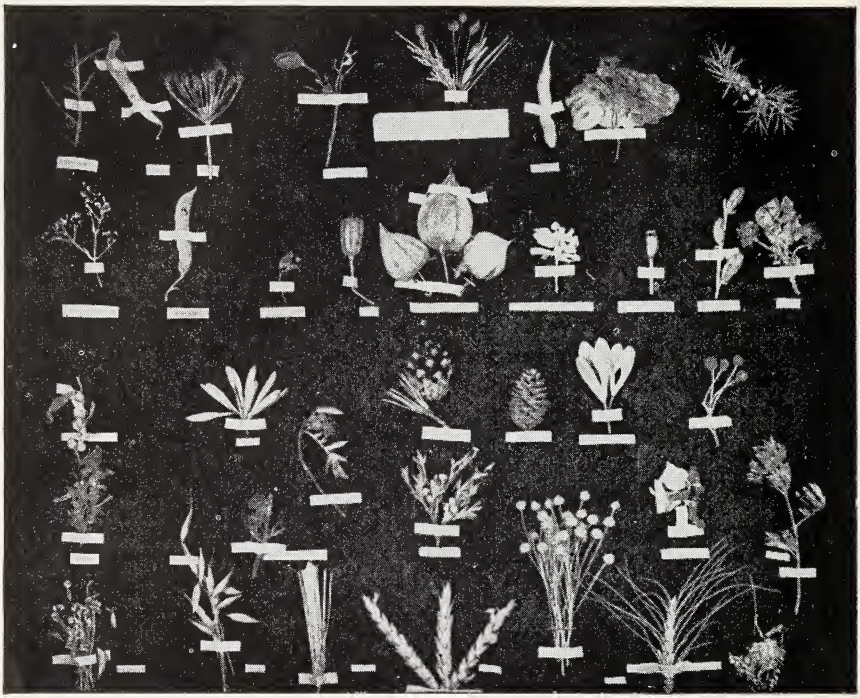
When observation, investigation, and reading fail to bring to light the particular information you want about a science problem, you should try to obtain it by discussing the subject with someone who has a knowledge of it. For example, you find an unfamiliar butterfly in your garden.

These pupils, who became interested in houses, are gathering first-hand information by (1) visiting a house under construction, and (2) asking the builder about kinds of wood, insulation, and methods of construction. (Bruce Pendlebury photo)

You notice its size and markings. You search through the best insect book available, but fail to find what kind of butterfly it is. The wise thing to do then is to take it to someone in your neighborhood whose hobby is the study of insects, and who most likely will be able to identify the butterfly. He will be glad to help you and will probably enjoy telling you many interesting stories about insects. You will find it helpful, and pleasant as well, to discuss your problems with other people who are interested in them.

### One method of studying science leads to another

Making first-hand observations often leads to reading and to discussion with others, and reading may lead to further investigation and experimenting. Used together, the four methods will help you to gather facts that will increase your knowledge and control and understanding of your environment.



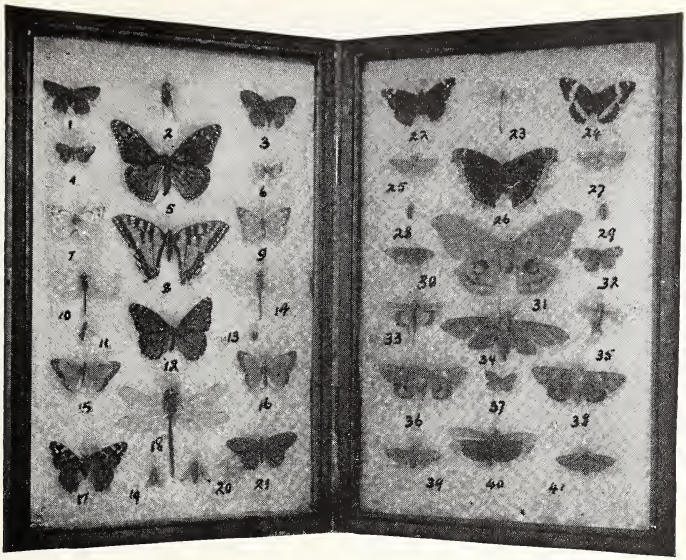
A pupil's collection of the fruit of trees, shrubs, garden plants, and field crops. Try to identify some of each. Observe the method used to mount and name each specimen.

**How do hobbies help your science studies?**

It was Hobby Day at school. Each of Miss Peterson's pupils had a hobby to display and explain.

Harold Parsons showed an insect collection. "At first," he said, "I was interested only in learning the names of the insects. Then I discovered that each has a life-history and habits of its own." As the other pupils admired Harold's collection, he was able to tell them where some of the insects laid their eggs, what the young looked like, what they ate, and many other interesting items of information about insect life.

You cannot possibly solve all the science problems that are about you; you cannot even read about them all. You will be forced to choose some and leave others. But which will you choose? Your own interests will be a guide. If there is one particular subject that attracts you, you can make it the centre of your activity. It will be your *hobby* — the work you do for the fun of it. Some hobbies, like collecting rocks, gardening, and watching birds, are forms of nature study.

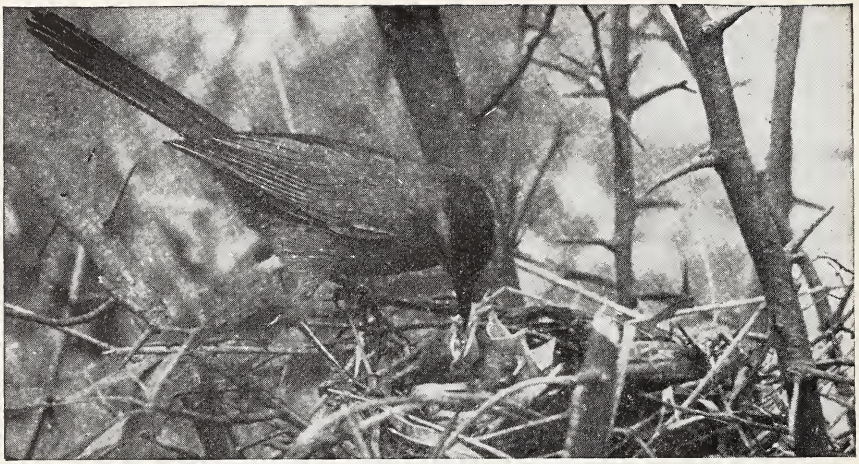


These insects were collected and mounted by a pupil in the autumn. The names of some of the specimens which can be seen most distinctly are: 5, monarch butterfly; 7, common white butterfly; 8, tiger swallowtail butterfly; 9, 15, 16, sulphur butterflies; 10, 14, 18, dragon-flies; 12, viceroy butterfly; 17, painted lady butterfly; 21, silver spot butterfly; 22, red admiral butterfly; 23, damsel-fly; 24, banded purple butterfly; 26, mourning cloak butterfly; 31, polyphemus moth; 33, 40, grasshopper; 34, sphinx moth; 36, 38, underwing moths.

Other hobbies, building model airplanes for example, provide manual training; and a hobby like photography combines workshop and out-of-doors activities. Every hobby suggests a number of related problems, and their solution leads to new interests. It is a good thing for everyone to have a hobby because of the pleasure, satisfaction, and relaxation it can bring him.

If your hobby is studying nature, you will learn more and more about your environment, and you will find that it grows more interesting all the time. When you make collections of leaves, fruits, wild flowers, weeds, rocks, fossils, or abandoned birds' nests, you discover that there is endless variety in nature. Building up your collection will provide you with a number of fascinating problems. Every good science hobby leads to further reading and investigation, and to new interests.

Jack Hopkins and his sister Edith had made gardening their hobby. Gardening is a hobby that offers a good opportunity to apply your knowledge of plants, suitable soils, soil foods, and the effect of weather on crops. All the methods of studying

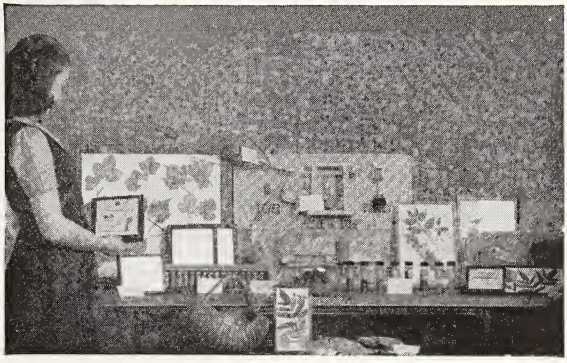


All day long is meal-time for this Catbird family. The study of birds is a fascinating hobby which can give a lifetime of enjoyment and be carried on in any season. (Hugh M. Halliday photo)

science are helpful in solving problems that you will encounter. You can observe plants and flowers and the conditions under which they flourish. Reading will keep you informed about new varieties of flowers and new methods of soil culture. You can find solutions to some of your problems by discussing them with experienced gardeners. And you can learn much about gardening by experimenting. If you start your garden with plants that are easy to grow, you will be able to improve it each year, as you make new discoveries. A garden that has been planned artistically and cared for scientifically brings pleasure to all who see it.

Two of the keenest young hobbyists were Tom Blair and Edward Wentworth. They had been studying birds. "There are too many to know in one summer!" exclaimed Edward. "I can hardly wait until next year to start again." And Tom added, "There are also the winter birds to study. We have an all-the-year-round hobby."

Many people have found that the study of birds grows more interesting as time goes on, and is a hobby that they can follow for a lifetime. It is not restricted to one season, but can be enjoyed throughout the year, as Tom explained. In the fall, migrants gather in flocks ready for the long journey to their winter feeding grounds. Some birds that have nested during the summer in the far north return with their families. Even people who have learned to identify many birds need to watch these families carefully, because the color markings of the young birds, or juveniles, are often different from those of their



A good beginning for a school museum. It includes collections of leaves, seeds, soils, insects, rocks, and fossils, as well as an aquarium.

parents. Day by day the migrants leave for the south. But with the cold weather, interest turns to chickadees and other birds that stay with us all winter. Their natural food is often hidden under the snow. Consequently one of the best ways of learning to know and make friends with winter birds is to erect feeding stations where they will gather.

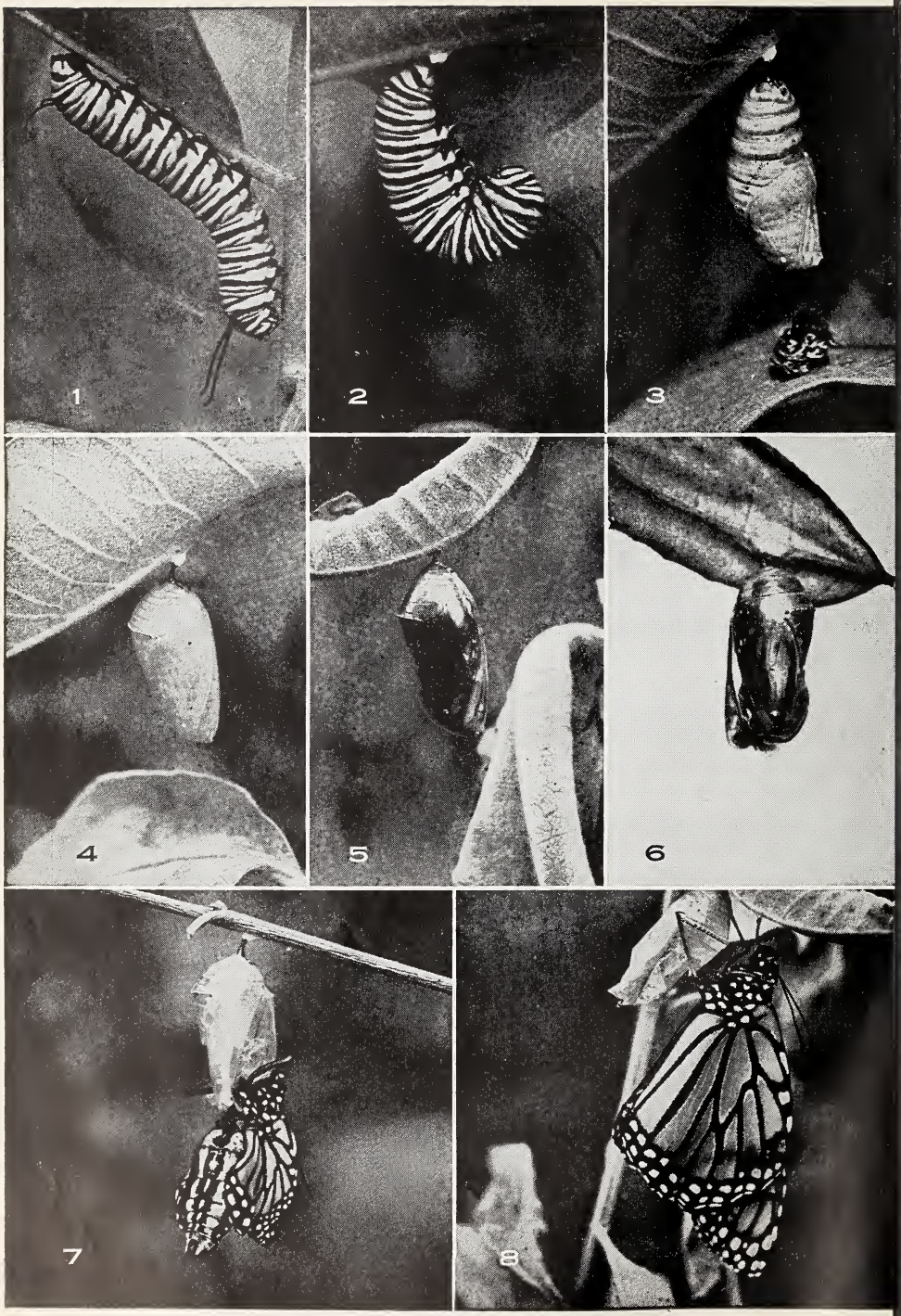
When the first warm spring days come, bird lovers watch eagerly for the return of the migrants from the south, and keep records of the dates they arrive. What a thrill they experience when they see the first robins, or the first flock of Canada geese winging their way north! Sometimes they identify birds that are very rare in their district. They listen to bird notes and often learn to recognize different kinds of warblers by their songs. With the warmer days, nesting begins. Bird lovers never molest a nest or annoy a mother bird. They watch for the hatching of the eggs, and see how the baby birds are fed and how they learn to fly. Later they watch them preparing to make the long trip south in the fall.

People who are interested in nature often choose photography as a hobby. A camera helps to develop powers of observation, and the search for good subjects for pictures leads to new interests. By studying the methods used to print and enlarge pictures, you may learn a great deal of science. By reading, you can keep in touch with new discoveries, like the recent developments in color photography, and so improve your own workmanship.

#### SOMETHING TO DO

The following are some general science activities that you might be interested in carrying out during the year.

1. Start a science library in your school. Bring from home old copies of science magazines and books containing interesting stories about scientific discovery and invention. A scrap book containing science clippings from the daily press would also be worth while. With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A man who has made both natural science and photography his hobby has used his camera to record the story of the wonderful change from caterpillar to butterfly. His story of the Monarch butterfly is told in the pictures on the opposite page and above, as follows: (1) The full-grown milkweed caterpillar ready to enter the chrysalid stage. (2) The caterpillar, with its mouth, spins a silken button to the under-side of a leaf or other suitable location. To this button it attaches its tail-end, and then swings head-down. (3) Within a day or two, the skin of the caterpillar splits and falls away. See the leaf below. (4) The caterpillar remains in the chrysalid stage until it emerges as an adult butterfly, from one to three weeks later. (5) After seventeen days, the chrysalid shown here had darkened. The developing wings of the butterfly can be seen forming within. (6) Without warning, the chrysalid splits, and the emerging butterfly commences to drag itself from its folded position. (7) Within a minute it somersaults out, and its wings begin to expand rapidly. (8) It remains clinging to its chrysalid until the wings have stiffened, when it is ready for flight. (9) The adult butterfly.

Monarch butterflies seem to possess some protective chemistry, for birds and other such enemies usually refuse to touch them. Sometimes during the fall, great flocks of these butterflies may be seen migrating south. Whole colonies of them may also be seen resting in trees or even in fields, where they cling to grass, weeds, and other small plants. (Photos by Hugh M. Halliday)

a little co-operation among pupils and an arousing of interest among parents and friends, a valuable addition could be made to the library in a short time.

2. Try to add books on science hobbies to your library. Write to publishing companies for lists of suitable books.

3. Organize a science museum as a school or community undertaking. Include collections of leaves, insects, birds' nests, wild flowers, heads of different varieties of wheat, oats, barley; samples of soil from different parts of the district; fossils, Indian arrow heads, etc. Any specimens related to the study of science could be included. Attach to each specimen a card showing the name of the article, where it was found, the date of finding, the name of the donor, and other important or interesting information. Select a committee of pupils to look after the museum, to receive new specimens, to enter them on permanent lists, and to arrange for space for displaying the exhibit. A good museum is always an important aid to the study of science.

4. Bring to school a collection you have made, and tell your class what you have learned about each item in the collection.

5. Invite to your school someone who has an interesting science hobby, and have him give a talk to your class.

6. During Education Week, or at some other special time, have a display of science hobbies, and invite your parents to the school. Whenever possible, be working at your hobbies. Be prepared to explain the details of the display to your visitors.

7. Arrange a science display for the spring of the year. Display apparatus you have made, and perform experiments using this apparatus. Show collections, charts, note-books, and any other work you have done in your science course. Give reports on science topics you have investigated.

While going through this introductory section, you have been reading and thinking about the method by which scientists work, and about scientific attitudes. Throughout the rest of the book, there will be many opportunities for you to work scientifically and to think and act in a scientific manner. Be sure, as you proceed from unit to unit, to refer again and again to the various parts of this section to make sure that your working methods and your thinking are becoming more and more scientific.

National Film Board

*Should the harvest fail for a single year, famine would depopulate the world.*

*—Ingalls*

# CHAPTER 1

CHAPTER 1

# PLANTS, THE WORLD'S FOOD FACTORIES

**Man uses plants to produce his food. If there were no green plants, there would be nothing to eat and little to wear. Even when you drink milk, you are using food made by plants. Why do we say that the leaves are the "workshops" of the plant? How are roots adapted for "pumping" water to every leaf and twig? A strong salt solution placed around the roots of a plant will kill it. Why?**

THE BREAD WE EAT, the food in the milk we drink, the cotton, linen, rayon, wool, or silk in the clothes we wear, the leather in the shoes that protect our feet, the wood of which our houses are built, the fuel that keeps us warm, the rubber in the tires on which our automobiles run, and even the paper on which this book is printed, all have been created by myriads of little factories that to us are just green plants. Some of these products, such as grain and cotton, come directly from plants in a form in which man can use them. Others, such as milk, meat, wool, and silk, come indirectly from plants, since the plants supply the food for cattle, sheep, and silkworms. Even the fish of the sea are dependent on green plants. Life on earth would be very different if there were no plants. You can readily see, therefore, that it is important that you should know something about how plants live and work.

## PLANT FACTORIES AT WORK

When we wish to produce food, we plant crops, such as wheat, potatoes, or apple trees. The plants that grow become "factories" for the manufacture of food. During the long summer days, each green plant is busy taking in water from the soil and carbon dioxide gas from the air, and combining them to form sugar and other foods. All green plants manufacture

A golden stream of wheat is being transferred from this combine to the waiting truck. The roots and stems of the wheat plants performed a great deal of work in supplying sufficient water to the leaves so that they in turn could produce this food supply. (National Film Board photo)

sugar. We know how sweet a beet can be, or an apple, or a kernel of corn.

If you were to visit a factory, you would find (1) stores of *raw materials,* (2) intricate *machines* in which the raw materials are changed into manufactured goods, (3) a power plant to furnish *energy* to operate the machines, (4) *manufactured goods* ready to be shipped away, and (5) in many cases, *waste products* that cannot be used.

In a plant, operations go on very much as they do in a factory. Raw materials (water and minerals from the soil and carbon dioxide from the air) are taken in and changed in the "machines" in the plant into manufactured goods, or food. Wastes are thrown away. The manufactured food is transported to other parts of the plant. In this chapter you will discover how these operations are carried out.

#### SOMETHING TO DO

1. Bring garden, field, and roadside plants to school. Observe that most plants have roots, stems, leaves, and flowers or fruit.

2. All plants have special *adaptations,* or ways in which they are fitted to live in their surroundings. For example, a dandelion has a long root in which it stores food and which enables it to obtain food and water deep in the soil. The leaves of plants are arranged so that they are exposed to light as much as possible. Mustard plants produce hundreds of seeds so that some will be sure to find a place to grow.

What adaptations can you find among the plants that you are studying?

### The scientific method

Science can do more than provide information for you. It can teach you not only to appreciate what scientists have done, but also to be a scientist in the things you do yourself. If you look at things carefully to see what they are like, and ask yourself what makes things happen the way they do, you have a scientific attitude. You can learn the scientific method of making experiments and finding the answers to your questions.

Ever since the time of Galileo, one of the earliest scientists, scientists have been working out a "method of attack," a way of finding out the basic truth of things, which is known as *the scientific method.* This method has been found to be reliable and accurate. It is possibly the greatest contribution that scientists have made to the search for truth.

Scientists have learned a very great deal about plants — they have found out how plants grow, how they carry on their work, how they manufacture food.

### Using the scientific method to study roots and their work

The first operations that take place in the plant factory are performed by the roots. The roots serve the plant in several ways: they anchor the plant in the soil, they absorb food (raw materials) from the soil and carry it upward to the stem, and in some cases they store reserves of food for the plant to use later in producing flowers and seeds.

As the pupils in Miss Peterson's class talked about roots, John Thomson wanted to know if all roots are alike. "How can we find out for ourselves?" asked Miss Peterson. The pupils decided they could gather roots of different plants and compare them.

#### SOMETHING TO DO

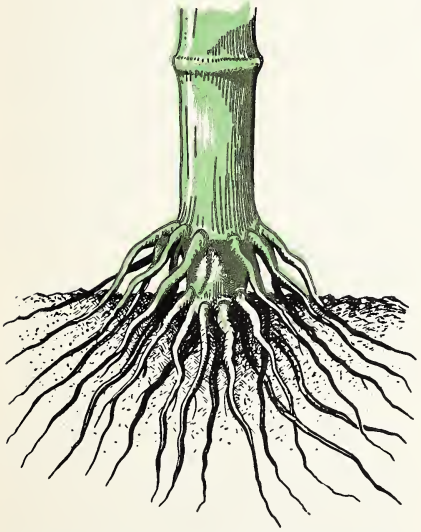
Examine the roots of common field and garden crops and weeds. Notice the differences in the roots of various plants. After reading this section, classify them as tap root systems and fibrous root systems. Which of the roots are *annuals,* and which live for *more than one year?*

If you have tried to pull up by the roots, dandelion, clover, or alfalfa plants, you know that such plants are held very firmly in the soil by a main root, which grows directly downward. Such roots may extend many feet down in their search for water. Branching from this primary or main root are many smaller secondary roots. These serve as feeders for the large central root. This type of root system is convenient for food storage, and is typical of plants having stems that

die down in the fall and grow up fresh from the root in the spring. It is called a *tap root system.* List all the plants you know that have tap roots.

Fleshy tap roots, such as those of beets, turnips, carrots, and parsnips, are used extensively as food both for people and for cattle, sheep, hogs, and other animals on the farm. A high percentage of the sugar used in this country is manufactured from the sugar beet.

Miss Peterson's pupils learned that wheat, corn, grass, onion, plantain, and a host of other plants have a type of root system that differs from the tap root system in that it has no large main root. Instead, it has a great many roots all about the same size, all arising from the base of the stem and extending in many directions through the soil. This is called a *fibrous root system.*



The corn plant has a fibrous root; it also sends out prop roots from the lowest joint or node.

Carefully investigating and making your own observations, as Miss Peterson's pupils did, is one good method of working in a scientific way. "However," said Miss Peterson, "if we are to use the scientific method to study the work of roots, we must do more than just investigate and observe. There are several well-defined steps that we must take. Let us see if we can work out the first step."

After some discussion, the pupils decided that:

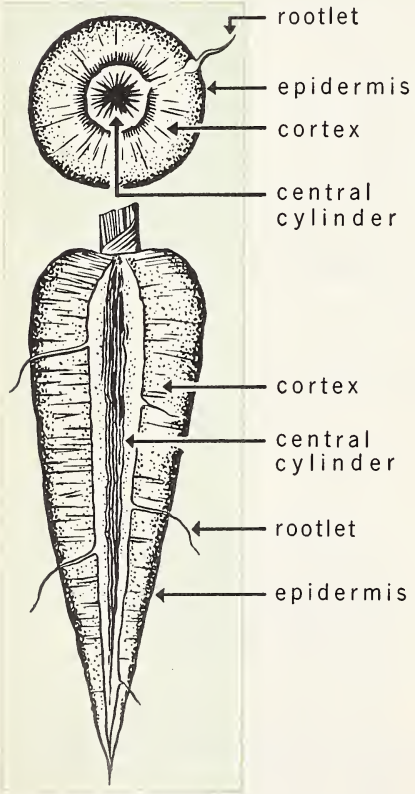
> 1. *The first step in the scientific method is to state clearly the problem to be solved.*

In the study of roots, it was agreed that the problem was: *What work do roots of plants perform and how are they fitted to do it?*

> 2. *The second step in the scientific method is to recall past experience and look for new information that may help to solve the present problem.*

Mary MacLean remembered watering a wilted plant. In a short time the leaves were firm and erect. "The water must have gone through the roots to the leaves," she said. Other pupils recalled similar experiences.

3. *The third step in the scientific method is to suggest, discuss, and criticize possible solutions, and finally to select, for checking by experiment or otherwise investigating, the one that seems most likely to be correct.*




A cross- and a lengthwise section of a carrot. Look for the same parts in other roots. What is the work of each part? Why is the cortex the sweetest part of a carrot?

*In the study of roots, what would you do next?* Think carefully before reading further.

Ralph Flaman thought that in order to understand how roots absorb food and carry it to the plants, and how they store the reserve food supply, it is necessary to know something of the parts of a root. "All roots, whether they are fibrous or tap, large or small, have the same parts," said Miss Peterson. "But you will find it easier to see the parts if you choose for study a large root such as the carrot."

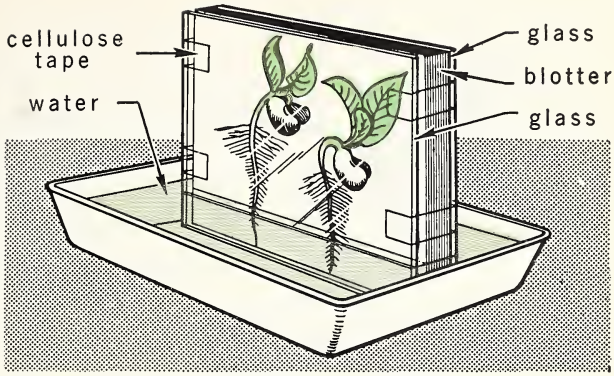
#### SOMETHING TO DO

Cut a cross-section of a carrot at the junction of a rootlet, and examine it. The tough outer part is the *epidermis.* It protects the root and helps to keep it from drying out. Observe the orange-colored, softer area just inside the epidermis. This is the *cortex,* the part of the carrot in which food is stored. Find in the centre of the root the *central cylinder.* This part contains the tubes for transporting sap. How does the central cylinder compare with the cortex in color, hardness, and taste? Look for *rootlets* in the cross-section. Do they arise from the epidermis, the cortex, or the central cylinder?

Make a drawing of a cross-section. Label all the parts.

Cut a lengthwise section through the middle of the carrot. Identify the parts as you found them in the cross-section, namely epidermis, cortex, central cylinder, and rootlet. Try to separate and lift out the central cylinder. To which part are the leaves attached?

Draw the lengthwise section, and label it fully.




A pocket garden, like the one illustrated, is easily arranged. It will enable you to study (*a*) root hairs, and (*b*) the development of the young plants as seeds germinate. Prepare a pocket garden for your classroom.

**Root hairs**

Water is very important to the welfare of a plant. If plants do not get water, they soon die. Water helps them to obtain food materials from the soil, serves as the liquid for carrying food to and fro, keeps the cells of the plants full and expanded, and promotes growth in the plants in a number of other ways.

To get into a root, water must be able to pass through the surface cells. As roots become larger and older, the outer cells become cork-like and practically waterproof. Water can then pass into the root only through those surface cells near the tip of the young root or rootlet. To increase the absorbing surface, thousands of cells on the epidermis send out little tubes called *root hairs.*

Walter Forbes found a book that helped the class to study root hairs. To learn more about these tiny parts of the root system, germinate some seeds and watch the roots as they grow.

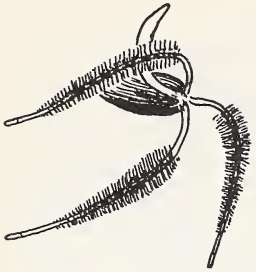
SOMETHING TO DO

Put some blotting paper in the bottom of a saucer or of a glass jar. Saturate the paper with water. Place some radish seeds or some wheat kernels on the blotting paper, and cover the saucer with a sheet of glass or with another saucer inverted. Keep in a warm place, and add more water from time to time if necessary in order to keep the seeds moist.

OR

Make a "pocket garden" like the one illustrated above. Place a blotter or paper towel and some seeds between two pieces of postcard-size glass held together by string or elastic. Stand the "garden" in one-half inch of water.

Observe the seeds as they germinate, and examine them closely after three or four days. Notice that the root develops before the shoot. Watch for the early development of root hairs, and see if the roots grow downward and the shoots upward. Locate, near the end of each root, a mass of root hairs. Examine them against a dark background with the naked eye, and then observe them closely under a magnifying glass. What do they



A germinating wheat kernel, showing root hairs.

look like? Where are they most numerous? Are there any at the very end of the root? How far back from the end do they extend? Estimate the number of root hairs on one-quarter inch of the root.

Make a series of drawings of a germinated seed, or seeds, showing shoot, root, and root hairs.

What happens if the root hairs are exposed to the air?

Sometimes it is possible to dig up a root and see the root hairs. However, they are usually torn off.

Root hairs are usually found in great numbers on all soil roots. They are extremely slender, closed tubes with frail walls. They are filled with cell sap. A root hair never grows to be a root. As the rootlet increases in length, new root hairs develop near the tip, and those farther back wither and die. The root hairs push in between the tiny soil particles and so come into close contact with the water that clings as a thin film around the grains of soil. Thus the absorbing surface of a root system is increased from twelve to fifty times, according to the variety of the plant of which it forms a part.

By this time, the pupils of Miss Peterson's class had investigated, by first-hand observations, the parts of a root. They were well along in the fourth step of the scientific method.

> 4. *The fourth step of the scientific method is to carry out an investigation or experiment to find out if the solution that has been selected as the most likely one is right or wrong.*

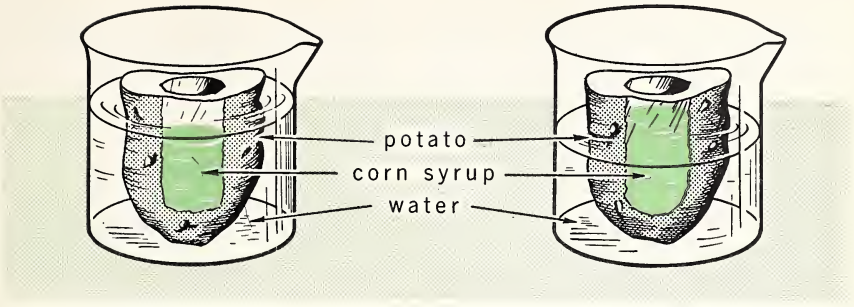
"But we haven't learned how water gets into the roots," objected Roy Kendal. "Perhaps it soaks in, as ink does into a blotter," suggested Helen Thompson. But several of the pupils were not satisfied with that explanation. Finally, they went back to Walter's book. They learned that water gets into roots by a very interesting process. You can learn about this process, as they did, by performing the following experiment.

### How does water get into the roots of plants?

This question can best be answered by setting up an experiment in which the conditions closely correspond to those that prevail when roots absorb water from the soil.

#### SOMETHING TO DO

*Problem.* — What happens when a strong solution is separated from a weak solution by a plant membrane?




Perform this experiment to find out how roots of plants take in water and minerals from the soil.

Note. — Solutions are formed when one substance dissolves in another, for example, sugar in water, or salt in water.

*Apparatus and Material.* — A large potato; some corn syrup or thick sugar solution; a dish of water.

*Method.* — Cut the end off a large potato. Hollow out the remainder. Put one inch of corn syrup or thick sugar solution into the hole. Stand the potato in a dish of water, making sure that the surface of the water is at the same level as the top of the syrup.

*Observation.* — After several hours, observe carefully what has happened.

*Conclusion.* — From the observations you have made, what do you conclude happens when a strong solution is separated from a weak solution by a plant membrane?

Alternative Experiments. — 1. Soak several dried raisins in water for two or three days. Change the water at intervals. Why do the raisins swell up? This is another example of the exchange of solutions through a membrane.

2. Soak slices of a slightly shrivelled beet in (1) water, and (2) salt solution. Explain why the beet remains shrivelled in one case and not in the other.

When two solutions of different strengths are separated by a plant membrane, such as the skin of a potato, the weaker solution passes through the membrane and mixes with the stronger solution. This process is called *osmosis* (from a Greek word meaning "to push in"). There is also a less rapid flow from the stronger to the weaker solution.

5. *The fifth step of the scientific method is to examine the results of the investigation or experiment in order to arrive at a conclusion.*

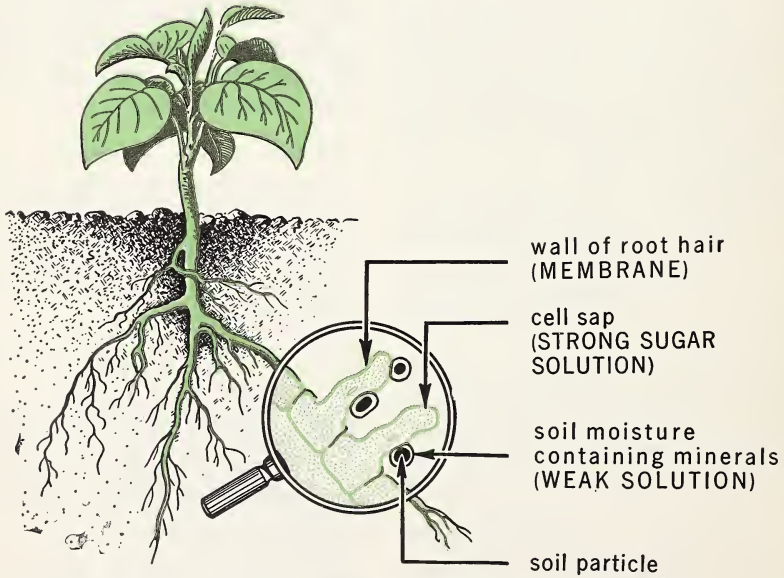
Miss Peterson's pupils put together all the information they had gathered about *roots, root hairs,* and *osmosis.* They checked their own observations by careful reading.

Finally, they decided that soil water enters the roots in the same way as the water passed into the

strong sugar solution in the foregoing experiment. The soil water containing dissolved minerals is the *weak solution.* It forms thin films around the soil particles. The root hairs push in between the soil particles and come in touch with the film moisture. The cell wall of the root hair is the *membrane* through which the soil water passes. In each root hair there is cell sap, which is a *strong sugar solution.* So we see that a weak solution (soil water) is separated from a strong solution (sap) by a plant membrane (the walls of the root hairs). The result is that the soil water passes from the soil into the root hairs. From the root hairs it moves from cell to cell and finally reaches the tubes through which it is transported to the stem and the leaves.

**STOP — READ — THINK**

In learning about plants, you are also being introduced to the scientific method of solving problems. But it is important to continue your study of plants while plants are available; so make the study of plants the main part of your work now. Later, there will be many opportunities to use the scientific method in other activities.




A diagram to illustrate how roots secure water and minerals from the soil. A part near the tip of a root has been magnified to show a few root hairs.

"There is one more step in the scientific method," Miss Peterson continued, "which we must always remember to follow. A scientist is not satisfied to stop when he has a solution to a problem. He wants to know more — to check further the accuracy of the conclusions that he has reached."

6. *The sixth step of the scientific method is to make a further test of the solution for its accuracy in other situations and to gather more information if this is possible.*

The pupils looked for further examples of osmosis. They soaked some prunes and raisins in water, and saw that osmosis operated to make them swell out. Ralph Flaman read in a garden book that too much fertilizer in the soil harms plants. He explained that this was because the cell sap in the plant passes *out* into the stronger fertilizer solution in the soil, and the plant dries out and dies. The pupils applied this information to kill some weeds by putting salt on them.

### What is an experiment?

We have seen that there are six steps in the scientific method of solving problems. In the fourth step, if possible, an experiment is performed. An experiment, therefore, is only one step in the scientific method. It is an excellent way to find the correct answer to some particular question. As we have seen, by experimenting, the class found the answer to the question: *How does soil water get into the roots of a plant?*

In performing an experiment, *five* steps must be taken. What five steps did Roy Kendal and the other pupils take in performing the experiment described on page 32? Here they are, set out briefly under five headings:

1. ***Problem*** — *what you want to find out.* Roy and his classmates decided that they wanted to find out how water gets into the roots of plants.

2. ***Apparatus and Material*** — *what you use in performing the experiment.* The pupils (page 32) gathered all the materials needed. What was used?

3. ***Method*** — *what you do.* The class set up apparatus in which a weak solution and a strong solution were separated by a thin membrane. They watched closely to see what happened.

4. ***Observation*** — *what you see* or *results.* The pupils saw that an exchange of liquids took place, but that much more of the weak than of the strong solution passed through the membrane.

5. ***Conclusion*** — *what you learn.* Review the conclusion that the pupils reached after performing the experiment on pages 32 and 33.

Whenever you perform an experiment, always follow the plan that has just been outlined. When you wish to

record an experiment in your notebook, arrange your notes under the five headings that are shown in the plan.

**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

1. Name the parts of a root. State a function (use) of each part.

2. Describe a root hair. Where are root hairs found? What purpose do they serve?

3. Compare a root hair with a root, using the following headings: *structure, purpose, length of life.*

4. Describe an experiment to illustrate osmosis. Make a labelled diagram to show what you used and what you did.

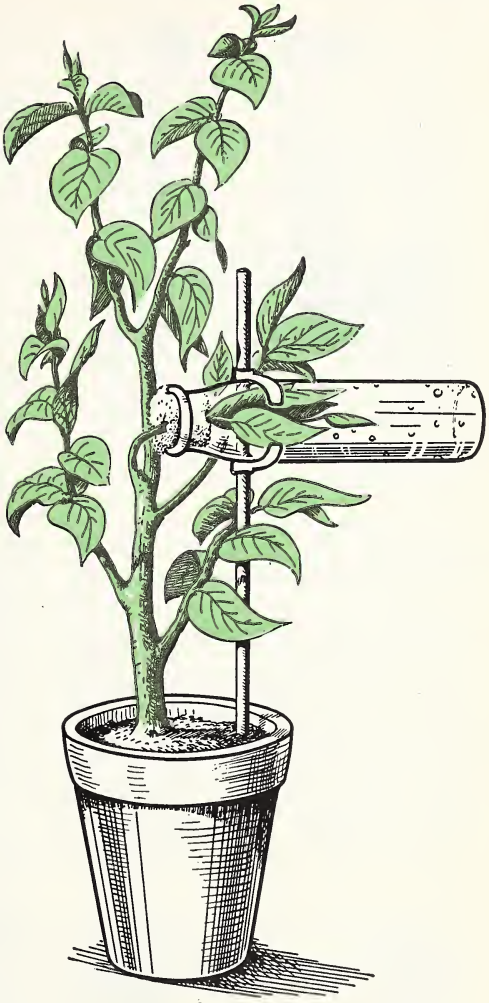
5. Use your knowledge of osmosis to explain how water gets into the roots of plants. Use the following table. If you wish, part (*b*) could be done largely by a labelled diagram.

| Comparison | (*a*) Osmosis in Experiment | (*b*) Osmosis in Roots |
|---|---|---|
| Weak Solution | | |
| Strong Solution | | |
| Membrane | | |
| What occurs | | |

6. Alkali soils contain a very large amount of soluble salts; as a result, the water in these soils is a stronger solution than the cell sap of a plant. Plants do not thrive in such soils. Apply the knowledge you have gained about osmosis to explain this.

## THE TRANSPORTATION SYSTEM OF A PLANT

When raw materials have been brought into a factory, they must be taken to the place where they will be turned into the manufactured product, and the product must then be taken to the place where it is to be used. In plant food factories, the soil water taken in by the roots must be taken to the leaves, and the food made in the leaves must, in turn, be carried down to nourish the stems or roots, or to be stored. This intricate and very complete "pipe line" or transportation system extends from the root hairs to the tips of the leaves.



Plants take in more moisture than they require. This surplus or waste water is given off through the stomata or tiny openings in the leaves.

Investigate this by inserting a few leaves of a plant into a small, *dry*, clean bottle arranged as in the diagram. Plug the mouth of the bottle with cotton batting. Place the plant in a warm window. Watch for the appearance of moisture on the inside of the bottle.

As a check, plug a second bottle but leave it empty. How does this serve as a check on what happens in the first bottle?

The process of giving off water through the stomata in the leaves of a plant is called *transpiration.*

**SOMETHING TO DO**

To find out for yourself that soil water is transported to the leaves, select a bleached or white celery stalk bearing leaves. Cut about one inch from the base, and stand the stalk in diluted red or green ink for several hours. Examine the leaves for the presence of ink. Cut cross-sections of the stalk, and note the parts through which the ink has risen.

To find the path by which water travels upward through the *root*, perform the following experiment:

Parsnip roots standing in ink. Find the part of the root in which soil water rises.

**SOMETHING TO DO**

Cut the lower ends from two parsnip roots, *fresh from the garden.* Let the roots stand overnight with the cut ends in about half an inch of diluted red or green ink. Cut a cross-section from one and a lengthwise section from the other. Where do you find traces of ink? Where, then, must the up-tubes in the root be located? From the observations you have made, what conclusion do you reach regarding the part of the root through which the soil water rises?

Make carefully labelled drawings to indicate the exact position of the tubes.

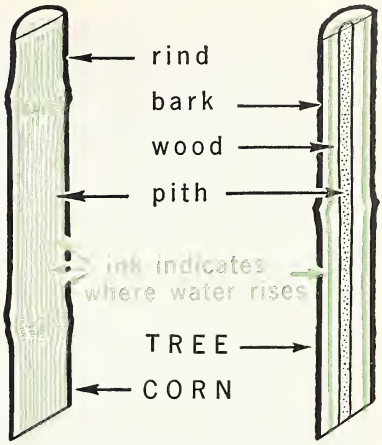
One of the functions of roots, as illustrated in the foregoing experiment, is to transport soil water containing dissolved mineral material upward to the stem. The tubes, or water ducts, that render this important service to the plant are situated in the outer part of the central cylinder. The tubes that carry the food downward from the leaves are in the same region of the root. These up-tubes and down-tubes in the root are grouped together in bundles called *vascular bundles.*

The *stem* forms the connecting link between the roots and the leaves of a plant. It also has a set of tubes through which the flow is upward to the leaves, and another through which the flow is downward. Where are the vascular bundles found in stems?

Remember that an experiment is used to solve a problem. We start with a problem and use an experiment to test one possible solution. When problems arise in your study of plants and in other sections of this book, try the experiments suggested, then devise methods of testing other possible solutions and report your findings to your class.

**SOMETHING TO DO**

Stand *freshly cut* twigs of willow, poplar, Manitoba maple, and geranium in diluted red or green ink for a few hours. Then use a sharp knife to make a cross-section and a lengthwise section of each twig. Where has the ink risen? Where then, are the tubes located that carry water upward through these stems? The up-tubes lie immediately under the inner bark, while the down-tubes are located in the inner bark. How are these tubes arranged?




Try this experiment to find out through what parts of stems soil water rises. Left: A corn stem and a tree stem are shown standing in ink. Right: These lengthwise sections of the stems show the parts in which water rises.

Make cross-sections and lengthwise sections of corn stems, and examine them closely. Filling the stem is a light, spongy material called *pith.* Observe the fibres that run through the pith. These are bundles of the up- and down-tubes called vascular bundles. Are they arranged in a ring, or are they scattered?

Next, stand a *freshly cut* corn stem in diluted red or green ink, and see if the ink rises in the vascular bundles.

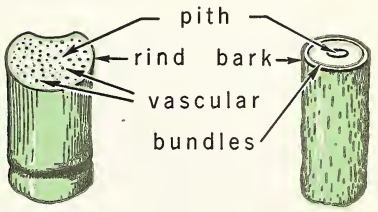
Make labelled drawings to show what you observed in these experiments.

In the *leaf,* the transportation system is provided by the veins, which also form the skeleton and give the leaf its shape. There are two kinds of veining, as you will discover by examining a variety of leaves.

**SOMETHING TO DO**

Observe the veins of leaves of the poplar, oak, elm, maple, and nasturtium. Notice that they are much branched and that they run into one another to form a fine network. Such leaves are *netted-veined.*

Next, examine leaves of corn, wheat, grasses, and lily. Observe that each of these leaves has many veins about equal in size running side by side from the base to the tip. These leaves are easily torn lengthwise. Try to tear one. They are *parallel-veined.* The veins in the leaves connect with the vascular bundles in the stems.




Cross-sections of corn stem (left) and a one-year-old tree stem. In the corn, the bundles are scattered throughout the pith. In the twig, they are arranged in a ring just beneath the bark.

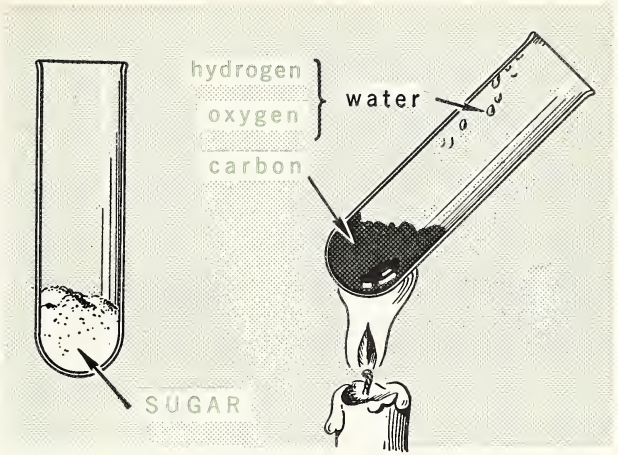
A simple, netted-veined leaf. Notice how the veins form a skeleton for the leaf.

Grass leaves, samples of which are illustrated above, are parallel-veined.

Your studies will have shown you that the transportation systems of plants include parts of the roots, stems, and leaves.

**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

1. Why is the transportation system of the roots, stems, and leaves an important part of the plant food factory?
2. Describe an experiment that illustrates through which part of a root soil water rises.
3. Describe an experiment to demonstrate that leaves give off water.
4. What are vascular bundles? How are they arranged in (1) tree stems, (2) corn stems?
5. Describe an experiment to show where water rises in a tree stem. Use the usual headings: *Problem, Apparatus and Material, Method, Observation,* and *Conclusion.* Illustrate the experiment with a drawing.
6. Describe two types of arrangement of veins in leaves. State two functions of the veins.
7. Using an example from your study of roots or stems, briefly outline the *six* steps of the scientific method.




Perform this experiment to discover the composition of sugar, a carbohydrate.

## PRODUCTS OF PLANT FACTORIES

We have learned how plants absorb and transport water. In the remainder of the chapter, we shall find out about the manufacturing process that takes place in green leaves.

Two of the chief foods that are made by leaves are starch and sugar. These are a source of energy for the plant itself and also supply man with much of his food.

#### SOMETHING TO DO

1. Place a teaspoonful of sugar in a *dry* test-tube or a long narrow bottle. Heat the lower end of the test-tube over an alcohol lamp. Note that drops of water collect on the upper part of the test-tube. This water has been formed from the sugar. The black substance that remains is *carbon.* Assuming that water is composed of *hydrogen* and *oxygen,* what is the composition of sugar?

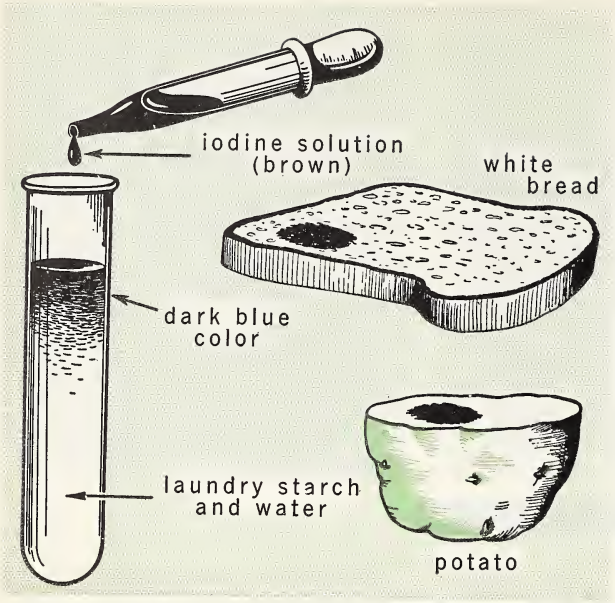
Because they are composed of carbon, hydrogen, and oxygen, starch and sugar are classed as *carbohydrates.*

2. The sense of taste will be sufficient to indicate the presence of sugar in plants. Taste a variety of plants, including sugar beets, watermelon, tomato, apple, orange, and other fruits. How do you know that these plants contain sugar?

### How can we test for the presence of starch?

#### SOMETHING TO DO

1. Put a *few* grains of laundry starch in a test-tube, cover it with water, and shake it well. Dilute some iodine solution with twice its own volume of water. Add a *few* drops of this weakened iodine solution to the test-tube. What color change do you observe?




Testing for starch. At the left of the illustration is the test for starch.

A few drops of iodine have been placed on the bread and the potato. Using your knowledge of the starch test, explain what the dark spots on the bread and the potato indicate.

What is the test for starch?

2. To find out if this is a *test for starch only,* test other substances, such as sugar and salt (which we know do not contain starch), and potato and flour (which we know do contain starch).

3. In the same way, test the following substances to see if they contain starch: milk, pie crust, cheese, cereal, meat, etc.

Which of the substances contain starch, and which do not? How do you know?

Starch is the only substance that will turn blue when it comes in contact with iodine solution. Sometimes this color is not pure blue, but is more of a purple or a purplish black.

This test is known as the *iodine test for starch.* You should remember how the test is performed, as it will be necessary for you to use it later.

### Carbohydrates are manufactured in green leaves

The three simple substances that compose carbohydrates — *carbon, hydrogen,* and *oxygen* — are put together in leaves to form sugar and starch. Where do leaves get carbon, hydrogen, and oxygen? Carbon is present in *carbon dioxide,* one of the gases of the air. When leaves are making food, they "breathe" in large amounts of carbon dioxide from the air. Water is composed of hydrogen and oxygen. As we have seen, water is taken in through the roots and passed up to the leaves. These two

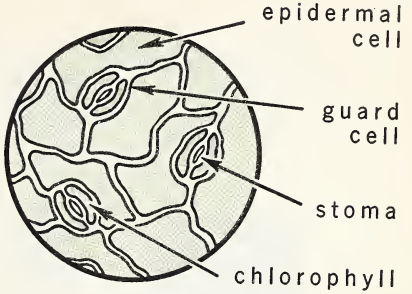
materials — carbon dioxide and water — are united in the leaf to form carbohydrates. This process results in the production of an excess of *oxygen*, which is given off through extremely small holes in the leaf which are known as *stomata* (singular — *stoma*). Although this oxygen is a waste product given off by plants, it is the most important gas in the air we breathe. Keeping the air well supplied with life-promoting oxygen is another way in which plants are useful to the animals of the earth.

The work of making carbohydrates in green plants is known as *photosynthesis*. Photosynthesis means "to put together by means of light."

From the substances obtained from soil water and air, the plant first manufactures *sugar*. Then some of the sugar is usually changed to *starch*, because starch is a more suitable form in which to store food temporarily in the leaf.

Most boys and girls have helped to make a kite, a playhouse, a model airplane, a doll's house, or perhaps a cake. For the construction of each of these, certain materials are required, and considerable *work* must be done to assemble the raw materials into the finished product. To build a playhouse, for example, one must saw boards and drive nails. This requires the expenditure of *energy* on the part of the builder. By energy we mean the *ability to do work*.

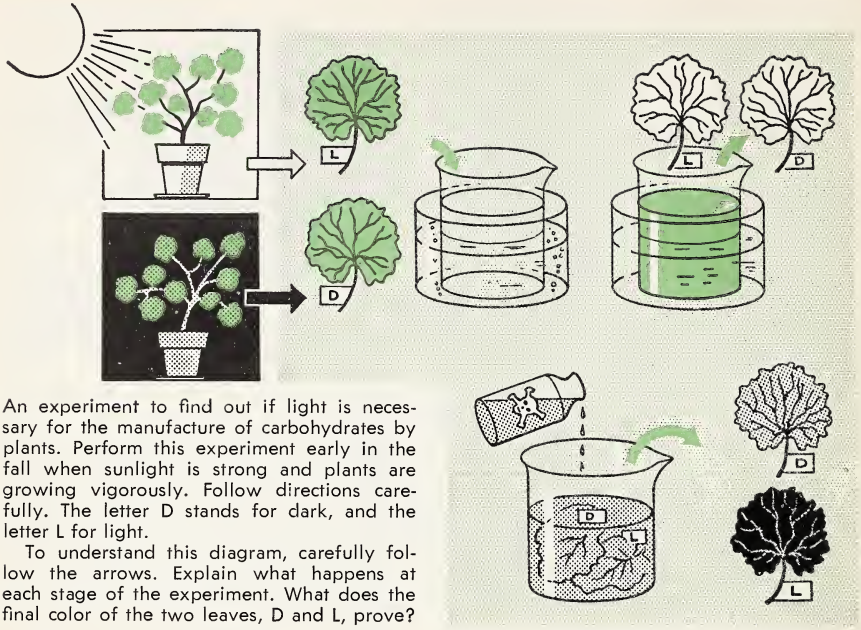
Similarly, work must be done to put carbon dioxide and water together in the leaves of plants to make




A small piece of the epidermis of a leaf, greatly enlarged. Note the tiny openings or *stomata*. Each opening is called a *stoma*. What is the work of the stomata?

carbohydrates. Where do leaves get the energy to do this work? Sunlight is a form of energy. In leaves there is a green substance called *chlorophyll* or leaf green, which has the ability to absorb sunlight, and the energy thus secured is put to work on the raw materials, carbon dioxide and water, to build them into sugar and starch. Thus the sun's energy is stored up in sugar and starch, to be used later by plant and animal life. This is a wonderful process, the secret of which man has not completely discovered. Scientists in many countries are continually experimenting in attempts to find out how chlorophyll is able to produce the world's food supply from such common materials as water, carbon dioxide, and the energy of sunlight. Perhaps this mystery will be solved during your lifetime.

Farmers and gardeners know that vegetables and grain produce greater yields when they receive plenty of sunlight. Is light necessary for plants to manufacture starch?




An experiment to find out if light is necessary for the manufacture of carbohydrates by plants. Perform this experiment early in the fall when sunlight is strong and plants are growing vigorously. Follow directions carefully. The letter D stands for dark, and the letter L for light.

To understand this diagram, carefully follow the arrows. Explain what happens at each stage of the experiment. What does the final color of the two leaves, D and L, prove?

**SOMETHING TO DO**

1. *Problem.* — Is light essential for the manufacture of carbohydrates by plants?

NOTE. — **This experiment should be demonstrated by the teacher.** *It will be more successful if performed in the afternoon of a bright sunny day in the fall or the spring term.* Be very cautious in handling the alcohol — it is inflammable. Boiling water also is dangerous.

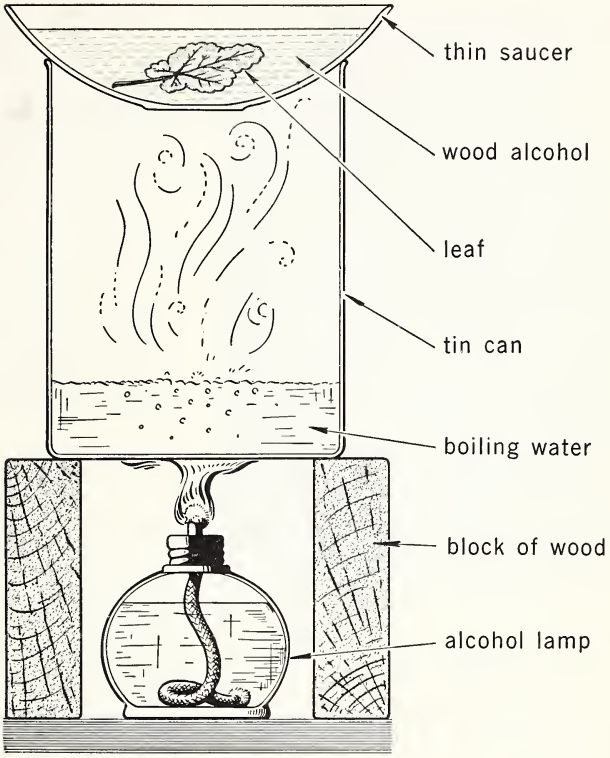
*Apparatus and Material* . — Two geranium or other green plants, *boiling* water, wood alcohol, iodine solution, a glass beaker, a flat pan.

*Method.* — Place one plant in bright sunlight and the other in the dark.

After at least *two* full days, dip a leaf from each plant in boiling water until well wilted. Clip the stem of one leaf so that you can identify the one which came from each plant. Place the leaves in a beaker about one-half full of alcohol, as illustrated. Set the beaker in a pan of *boiling* water. As the water cools, change for fresh *boiling* water every five minutes, to keep the alcohol as *hot as possible.* The leaves should remain in *hot* alcohol for from ten to fifteen minutes, or until they are almost white. It may be necessary to add more alcohol.

Wash the leaves in lukewarm water. Then dip them into a solution of iodine for several minutes. Again wash the leaves, and spread them out to examine them.

*Observation.* — When the leaves were dipped in the iodine solution, what change in color was noted?




A second method of removing the chlorophyll from leaves. It may be necessary to replenish the alcohol several times before the leaves become white. ***Extreme care must be exercised not to spill alcohol over the flame of the alcohol lamp.***

Be sure that the blocks of wood used to support the tin can are thick enough to stand firmly.

*Suggestion:* Remove the lamp while pouring more alcohol into the saucer. ***This is a teacher experiment.***

The test for starch in leaves is very interesting and important. It helps us to understand the process which is the first step in enabling man to satisfy his basic need for food.

*Conclusion.* — Which leaf showed the presence of starch? Is light necessary to enable plants to manufacture carbohydrates? What makes you think so?

Draw a series of your own diagrams to show what you used, did, and learned in this experiment.

2. Is chlorophyll necessary for photosynthesis? Test for starch a leaf from a variegated (green and white) geranium or a foliage plant that has been exposed to bright sunlight. Does the part of the leaf that contained no chlorophyll give a test for starch? Is chlorophyll essential for starch-making? Give reasons for your answer.

3. To learn how plants reach for sunlight, set a potted plant in a sunny window. After a couple of days observe the position of the leaves. Turn the plant around, and a day or two later observe the leaves again. Do you notice any change in their position?

4. To learn how sunlight affects the production of chlorophyll in plants:

(*a*) Germinate some seeds, keeping in complete darkness all parts of the seedlings that develop. Observe the

color after several days. Then place the seedlings in the light, and notice what happens.

(*b*) Observe potato tubers that have been sprouting in the dark. Place one or two in the light. Observe them daily for several days. What changes take place in the color and development of the sprouts?

(*c*) Place a board over a small patch of green grass in the lawn. Raise the board from time to time, and notice the color of the grass.

### Photosynthesis is a manufacturing process

Photosynthesis may be compared with a manufacturing process, as you will realize if you study the following table setting forth the chief points of resemblance.

### What does a plant do with the carbohydrates it makes?

The carbohydrates manufactured in the leaf are transported by the sap to the various parts of the plant, where they are used in different ways. Some of these carbohydrates are used to build up new cells, and other food materials, such as protein, which are necessary for the growth of the plant. Others are stored away in the root, stem, leaf, or seed for future use. It is important to remember that the energy from sunlight is stored in the food materials not used up immediately by the plant. When we eat food, the energy in it is made available for use in our bodies. We shall learn more about protein and other food materials later in our study of foods.

#### SOMETHING TO DO

1. A satisfactory test for *protein* is the odor that is given off from it when it burns. Burn some lean meat, wool, fur, hair, or feathers in order that you may recognize this odor. Then burn peas, beans, soybeans, peanuts, corn, and wheat to see which of these contain protein.

2. Put a drop of lubricating *oil* on a paper. Hold the paper near the window and notice whether light passes through the oil spot. Crush peanuts, soybeans,

| Comparison | Furniture Manufacturing | Photosynthesis |
|---|---|---|
| 1. Place | factory | leaf |
| 2. Raw material | lumber, screwnails, varnish | carbon dioxide and water |
| 3. Machinery | saw, plane, etc. | chlorophyll |
| 4. Power | electricity or steam | sunlight |
| 5. Product | table, chairs, etc. | carbohydrates |
| 6. By-product | shavings, sawdust | oxygen |
| 7. Working hours | 8 a.m. to 6 p.m. | daylight |

beans, wheat, corn, and other seeds on a piece of paper to see whether they contain oil.

3. Cut cross-sections of parsnips, carrots and turnips. Pour weak iodine solution over the cross-sections. Which part turns blue? Which part remains unchanged? Where, then, is *starch* stored in these roots?

Make a drawing to show the result you obtained.

4. Examine a potato tuber to discover the buds, or eyes. Then place the potato in a window where it will receive warmth from the sun, and observe it from time to time as the buds develop into stems.

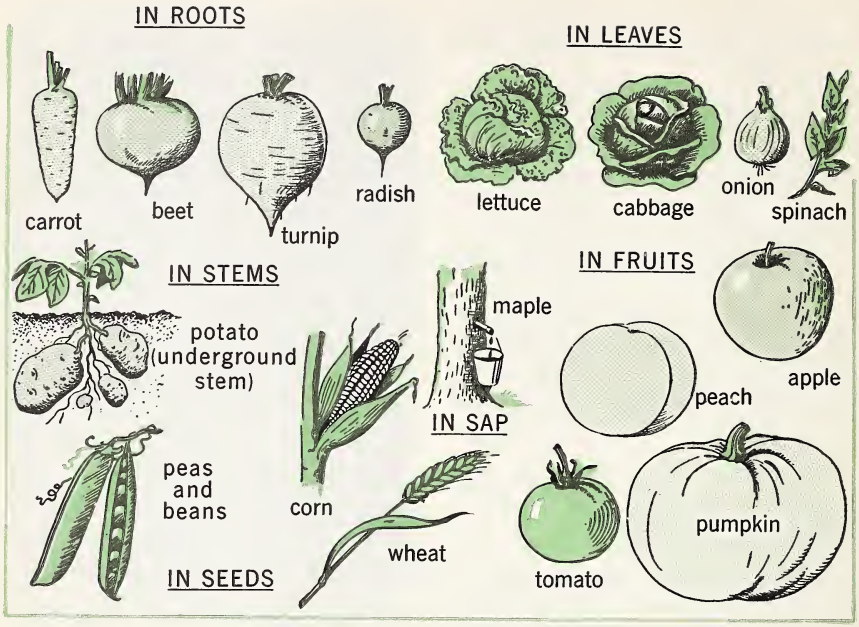
Test a slice of potato for starch. What purpose is served by this supply of starch stored in the tuber?

Biennial plants, such as the parsnip and the carrot, store large reserves of food in their roots during the first year of their growth. The food is stored chiefly in the form of starch for use the following year in the production of flowers and seeds. Many perennials, such as trees, also have roots that are capable of storing food. Roots of annuals, such as spring wheat, corn, and tomatoes, for example, are not adapted for storing food.

Many plants store in their stems reserves of food, which they can either draw upon themselves or use in reproduction. The sugar-cane plant, for instance, accumulates such large supplies of sugar in its stem that the plant is cultivated for the sugar it affords. Asparagus tips, which are but stems of asparagus, and maple syrup, the condensed sap of the sugar maple, also are examples of delicacies that plants provide by their habit of storing surplus food in their stems.

The leaves of these huge trees, grown on Vancouver Island, have manufactured a large amount of food to produce the wood and other materials that have been used in their growth. (British Columbia Government Travel Bureau photo)

The common potato is perhaps one of the best known examples of stems that are especially adapted for food storage. This tuber, often incorrectly regarded as a root, is a highly specialized underground stem, carrying generous food reserves for reproduction. When we plant pieces of potato tubers, new plants grow from these parts of the old plant.




The food manufactured by green plants is stored in roots, leaves, stems, seeds, and fruit. Man has learned to use these parts of the plants as a means of providing for his own basic need for food. Give *one* example, not illustrated, of a root, stem, leaf, seed, and fruit used by man for food.

**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

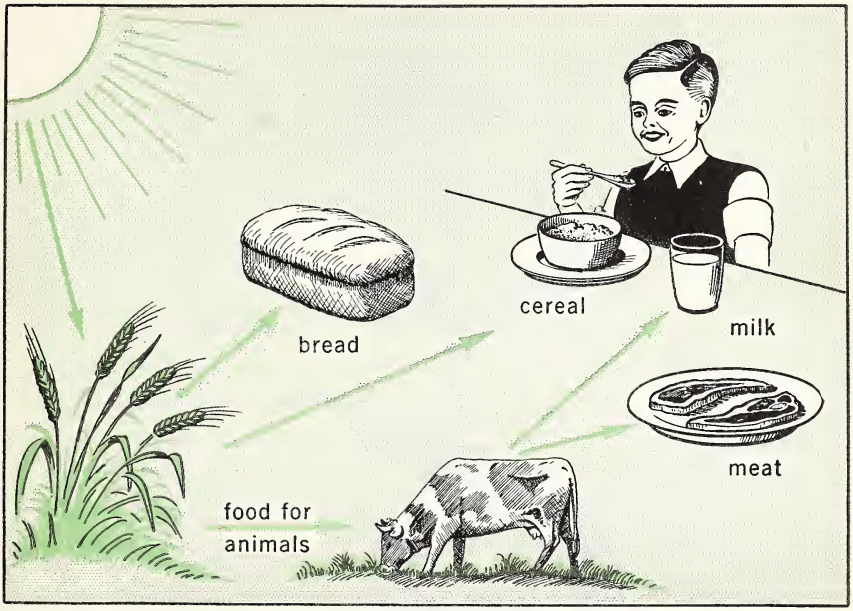
1. What are carbohydrates? Name two. Of what are carbohydrates composed?

2. Describe a test for starch.

3. Describe fully the process of photosynthesis or carbohydrate manufacture, using the following questions as a guide: (1) What raw materials are used? (2) Where does the plant get these raw materials? (3) Where and when is the process carried on? (4) What is the source of the energy used to do the work? (5) Why is leaf green or chlorophyll necessary? (6) What products are made? (7) What is the by-product and what becomes of it?

4. Describe an experiment to show that sunlight is necessary to enable leaves to manufacture food. Illustrate with drawings.

5. How do plants use the carbohydrates they manufacture? Discuss storage of food in stems and roots of plants.




Plants produce all of the world's food supply, using the sun's energy in the process. Animals, however, cannot make their own food. They secure their energy by eating plants or by eating animals that have fed upon plants. Animals are therefore dependent upon plants, and all life is dependent upon sunlight. Show that, regardless of the food he eats, the boy in the above illustration is obtaining his energy from the sun.

6. Show that we depend for our food either directly or indirectly upon foods that plants make.

7. The energy that a boy uses when he plays a game of football comes from the sun. Is this statement true? Explain.

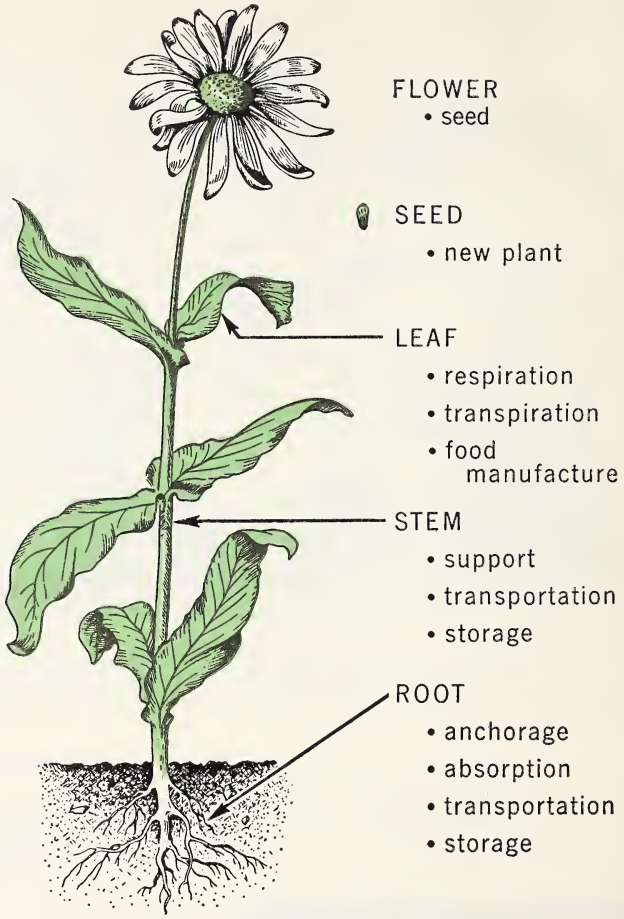
## WHAT HAVE YOU LEARNED?

### IMPORTANT IDEAS AND UNDERSTANDINGS

A

1. Practically all of our food comes directly or indirectly from plants.
2. Green plants manufacture sugar in the presence of sunlight.
3. Chlorophyll is necessary for photosynthesis.
4. Plants store starch in roots, stems, leaves, and seeds.
5. A problem is a question or a situation that presents a difficulty.

Use this drawing to test your knowledge of how the life processes of a plant result in a supply of food for man. Each label should have a meaning for you. Explain in your own words, using the labels as a guide, the story of how a plant lives and grows.




(a) The five sentences at the bottom of page 49 are all true statements of important science ideas and understandings. Read and discuss them carefully as a review of this chapter.

(b) The following sentences describe situations in which some of these ideas apply. To test your ability to apply ideas to actual situations, match sentences in A with sentences in B to which they apply.

B

1. After a good dinner of meat, vegetables, milk, and fruit, Lou Baker was ready for a full afternoon's work.

2. Some plants, such as toadstools, have no chlorophyll. They must depend upon other plants for food.

3. Gordon Wayne and George Grant were comparing two carrots. They decided that before they could determine which was the better carrot, they would have to find out in which part of the carrot food was stored.

4. In our daily diet, bread and potatoes are good sources of carbohydrates.

## IMPORTANT SCIENCE TERMS

A

| | | |
|---|---|---|
| scientific method | osmosis | stomata |
| cortex | membrane | photosynthesis |
| epidermis | root hairs | chlorophyll |
| tap root | carbon dioxide | carbohydrates |

To show that you understand and can use the science terms listed in A, match with situations described in B those terms which apply.

B

1. Near Malcolm Gray's home was an area of alkali soil. Malcolm learned that many plants could not grow there. The alkali salts cause the soil solutions to be stronger than the sap solution in the plants.

2. The pupils in Miss Peterson's class placed a plant in a dark cupboard. The plant became sickly. It could not manufacture the food it needed.

3. When a scientist faces a problem, he thinks of all possible solutions, then selects one and tests it by experimenting.

4. During the process of manufacturing sugar, green leaves combine a gas from the air with water from the soil.

5. Joan Graham prepared a microscope slide using the skin of a geranium leaf. She was interested in looking at the tiny openings in the leaf.

6. One day Roger Forbes and Charlie Hunt dug up a root. Near the tip of it, they saw many tiny white thread-like parts.

## SCIENTIFIC METHOD AND ATTITUDES

1. Miss Peterson's class decided to keep a geranium plant in the school. Tom Smith suggested that it would be a good idea to put fertilizer on the soil in the flower-pot. The pupils knew very

little about growing house plants. However, they bought some fertilizer and put a heaping teaspoonful on the soil and watered it well.

In a few days, the plant wilted and eventually died. The class decided that fertilizers harm rather than help house plants. This we know is the wrong conclusion.

What important step or steps in the scientific method did the class omit (1) before applying the fertilizer, and (2) after using the fertilizer?

2. Mary Oliver's class was discussing the topic: *Animals depend upon plants for practically all of their food.* Mary wasn't paying much attention. She had already made up her mind that the statement was wrong. "Fish," she said, "live in the water -- they do not eat plants. Earthworms eat the soil itself. Birds feed upon insects."

(*a*) Was Mary showing a scientific attitude? Why or why not? Remember that she had three examples to support her argument.

(*b*) What would you have done, if you had been in Mary's place?

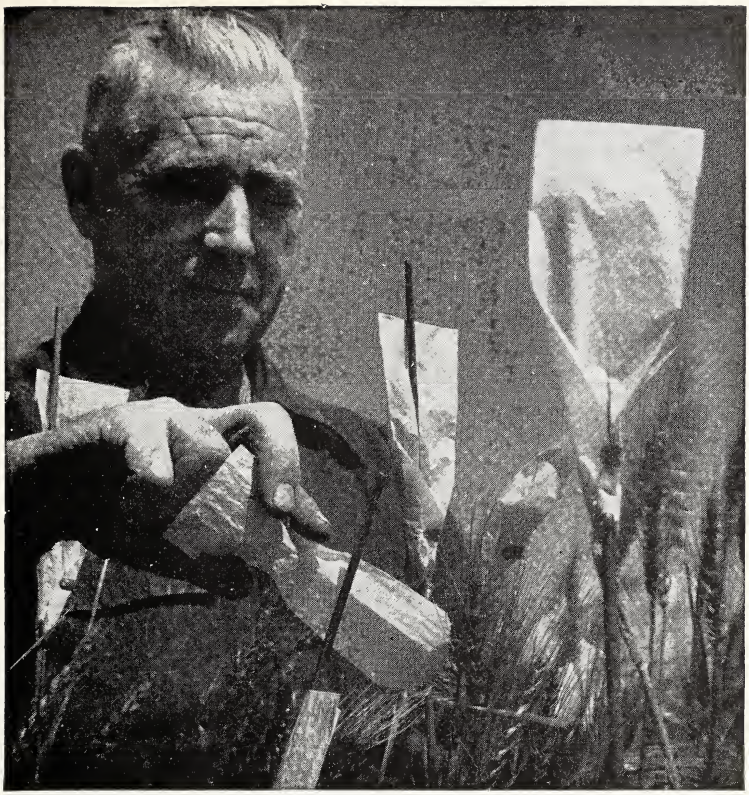


Photo by Malak, courtesy Experimental Farms Branch, Ottawa

*O Painter of the fruits and flowers!*
*We thank Thee for Thy wise design*
*Whereby these human hands of ours*
*In Nature's garden work with Thine.*

—*J. G. Whittier*

CHAPTER 2

CHAPTER 2

# IMPROVING PLANTS TO FEED THE WORLD

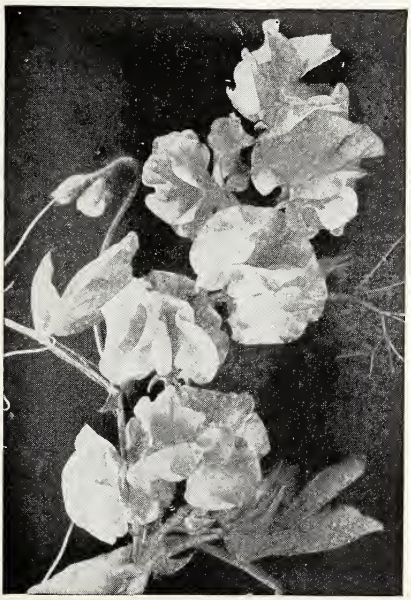
**The farmers of New Zealand found that they had to import bumble-bees before they could raise red clover successfully. Can you explain why? How do plants produce seeds? Do you know that our grains, vegetables, and fruits once grew wild? The cultivated varieties of our crops are much superior to their wild ancestors. Canada has been referred to as "the bread basket of the world." If the wheat produced in Canada in a year were put into one train, it would stretch from Halifax to Vancouver. The growing of crops presents many problems. How has science increased our ability to improve plants and thus produce so much food for a hungry world?**

THE EARLIEST historical records tell of the cultivation of wheat and barley. Many other plants, such as flax, rice, cabbages, onions, turnips, peaches, pears, apples, olives, figs, and dates, have also been grown in various parts of the world for thousands and thousands of years. *Barley* still grows wild in Palestine; not long ago, a plant explorer discovered wild *wheat* growing there also. Wheat has been grown for so long that no one knows who were the first people to grow it. Pictures found in the ancient tombs of the Egyptians show that they grew wheat 6000 years ago. Now it is grown in almost every country. *Oats* are descendants of the wild oats of Asia Minor. *Alfalfa* is a native of Persia, where it is still to be found in the wild state. *Sweet clover* first grew in central Asia. *Corn* originated in Mexico, and was under cultivation when Columbus discovered America.

Common plants of Southern and Western Europe were the ancestors of our *cabbages, cauliflowers,* and *beets. Potatoes* still grow wild in Chile and Peru. *Apples, pears, plums,* and *cherries* were brought to this country from Europe. *Peaches* originated in China.

Most of our cultivated plants show little resemblance to their early ancestors. This is because man has been constantly changing the more valuable kinds of plants to make them more useful, that is, more productive, earlier ripening, and more resistant to disease, drought, and other adverse conditions. When new territories are opened for agricultural purposes, it is frequently found that existing varieties of crops are not satisfactory; and in older settled districts, conditions sometimes change so that crops that once produced good yields and were of good quality no longer do well. To overcome such difficulties, men are constantly searching for new varieties of plants. Scientists go to distant parts of the world looking for plants that may be of value; some seek to create new varieties by cross-breeding, and others try to find better strains by a system of selecting the best plants in existing varieties. Frequently all three methods are combined in the work of improving crops.

Bountiful crops are necessary to provide the people of the world with food. Since man first began to grow crops, he has worked to improve them. Today, crops of all kinds yield more and have greater resistance to disease, drought, and other unfavorable conditions than crops of even a few years ago. (Associated Screen News Ltd. photo)



Because of the scientific improvement of the sweet pea, this plant now has many flowers on each stem. (Wm. Rennie Seeds photo)

Producing new varieties of plants requires great skill and patience, but many people find true pleasure in it, and make it their life's work. Others, too, for whom gardening is only a hobby or pastime, have produced new varieties of flowers.

## HOW FLOWERS ARE FITTED TO PERFORM THEIR WORK

Walter Forbes and Gary Morin were spending a week-end on a farm. They were the kind of boys who were curious about the things around them. On the farm, they wanted to learn about crops, soil, and livestock.

One day, Mr. McRae, on whose farm they were visiting, showed them a fine crop of wheat. He explained that the wheat was a variety called Selkirk. "A year ago," he said, "I grew another variety, but it rusted badly."

"What is a *variety*?" asked Gary.

Mr. McRae then explained, "A variety is a kind of wheat, or other crop, with certain fixed characteristics. For example, the wheat variety Thatcher is susceptible to a disease known as 12B rust. The variety Selkirk is not susceptible to this disease. If a farmer sows Thatcher, it may be damaged by 12B rust. If he sows Selkirk, it will not rust."

Walter then inquired how the different varieties have been developed.

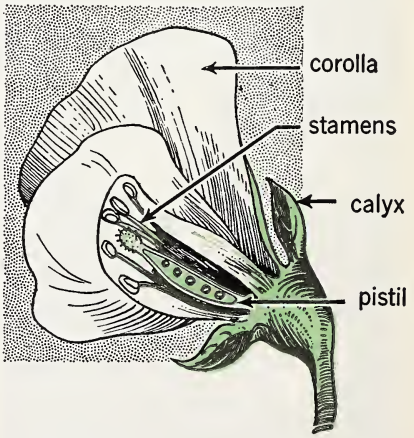
"That's a long story," replied Mr. McRae. "Some parts of the story go back many years. Other parts have taken place more recently."

Before they left the farm, the boys had gathered a great deal of information about varieties and plant improvement. One thing Mr. McRae had emphasized was that in order to understand how scientists are able to develop new varieties of plants, we must know something about the various parts of a flower and the method by which it produces seed. "And the best way to learn about the parts of a flower," he continued, "is to examine several specimens."

When Gary and Walter returned to school, they suggested that the class make a study of flowers and plant improvement. The other pupils readily agreed. Miss Peterson, their teacher, said that such a study would be very interesting and worthwhile.

### How flowers are fitted by nature to produce seeds

Flowers vary greatly in appearance, but in the arrangement of their parts and in the work they do, they are very much alike. The function (use) of every flower is to produce seed.




A lengthwise section through a sweet-pea flower, showing the parts in relation to one another. Make a section through a blossom, and locate these parts.

**SOMETHING TO DO**

*Materials Required.* — Several sweet-pea blossoms and other large flowers, such as single petunias, morning glories, single nasturtiums, snapdragons, hollyhocks, and others, for members of the class; a pocket-knife or needle. A magnifying glass or a hand lens will be helpful.

*Method.* — Notice, at the base of the flower, several green, leaflike parts, the *sepals.* Together they form the *calyx.* The calyx supports and protects the more delicate parts of the flower. Examine the colored parts of the flower. Each is a *petal,* and together they form the *corolla.* Why do flowers usually have large, showy corollas?

If you are examining sweet peas, work carefully in order not to damage the delicate parts inside. Separate the two petals that are joined together, then remove all the petals. This exposes to view a number of thread-like parts called *stamens.* The enlarged tips of the stamens are the *anthers.* Find the yellow powder contained in the stamens. This is *pollen.* It plays an important part in the production of seeds. The work of the stamens is to produce pollen.

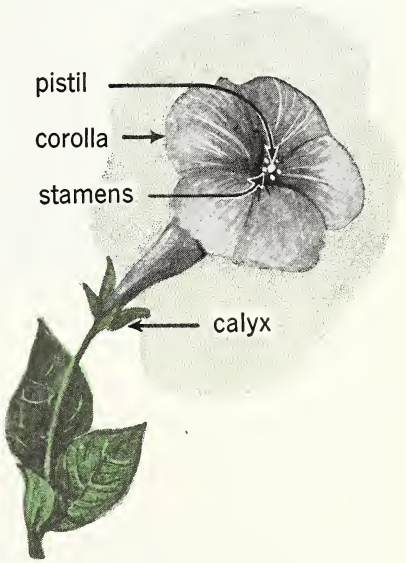
Carefully open and remove the tube formed by the lower part of the stamens. The part of the flower enclosed by the stamens is the *pistil.* Notice that the pistil has an enlarged end, called the *stigma,* and an enlarged lower section, the *ovary,* which is attached to the end of the flower stalk. Joining the stigma and the ovary is a long, slender section called the *style.* Hold the pistil up between you and a light (a window). Observe the small round bodies within the ovary. These are known as *ovules* and are the beginnings of seeds. Cut open several ovaries, and observe the seeds in various stages of development.

NOTE. — Be sure to look for flower parts in several other flowers now in bloom; if possible, examine some of the flowers mentioned in the list of materials. Proceed in much the same way to find the calyx, corolla, stamens, and pistils.

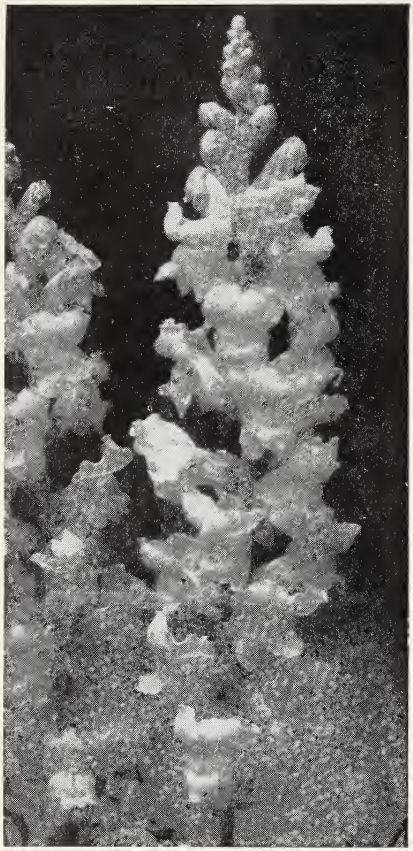
Make a page of drawings to illustrate the parts of a flower, using a fresh specimen as a guide. *Draw* (1) the corolla with the petals spread out, (2) the stamens and pistil on the stalk, (3) a pistil by itself, (4) the stamens by themselves. Label each drawing fully.

### Each part has its own work to do

One of the chief functions of every plant is to reproduce its kind. This,




A petunia flower. The corolla is funnel-shaped. It is composed of five petals joined together. Find these parts on your specimen. Locate the stamens. Where are they attached?



Snapdragon spikes. If you press the sides of the corolla tubes with your fingers, they will snap open. (Ferry-Morse Seed Co. photo)

in the case of a flowering plant, is accomplished largely by the production of seed, which, under favorable conditions, will develop into new plants. The flower, as our study has shown, has four chief parts: calyx, corolla, stamens, and pistil. Each of these parts is especially equipped to perform its own particular service in the production of seed. The stamens, for instance, are fitted with anthers for producing pollen. The pistil is equipped with a large, sticky stigma for catching pollen, and in its ovary it has ovules all ready to grow into seeds. Because no seeds are produced unless both stamens and pistil are present, these are the essential parts of the flower. The calyx, which is rather strong and tough, is well adapted to protect and support the more delicate parts. It also serves as a protective covering for the flower bud. Highly

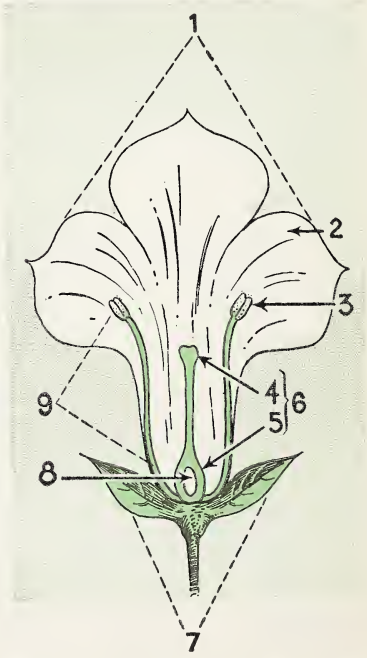



Diagram of a typical flower. Identify the following parts with numbers from the diagram: corolla, ovule, petal, anther, pistil, calyx, stamen, stigma, ovary.

colored, sweetly scented corollas usually perform the function of attracting insects. Later, we shall discover what part insects play in the production of seed.

### How do different flowers resemble one another?

All *complete* flowers have sepals, petals, stamens, and pistils, although the form and arrangement vary widely in different flowers. However, you will be interested to know that some flowers lack one or more of the parts that you discovered. Some have no stamens. Others lack pistils. Pumpkins, squash, cucumbers, and watermelons are examples of plants with such flowers. The great variation in the structure of flowers and the marvellous ways in which they are fitted to perform their work are never-ending sources of wonder to all who study flowers.

#### SOMETHING TO DO

1. Examine as many flowers as you can, both in the fall and in the spring, to learn more about their structure. *Most flowers can be studied without pulling them apart.* Make drawings of several of the flowers that you examine.

2. Pressing and mounting specimens of flowers will open the way to further experience with the structure and work of their parts. Make a collection of your own, or work with other members of your class to make a school collection of the flowers of plants that are common in your locality.

3. Flower Heads.—Carefully examine the flowers of *cosmos, zinnia, marigold, aster, sunflower,* and *dandelion.* In each *head* are found many individual *florets.* Break open a flower head and examine an individual floret. How many petals has it? What other parts can you find? What is the purpose of the outside ring of larger, showy petals in the heads of cosmos and sunflower?

#### TEST YOUR KNOWLEDGE AND UNDERSTANDING

1. Name the four chief parts of a complete flower, and state the function of each part.
2. Explain how each part of a flower is adapted by structure to perform its function.
3. Which part or parts of a flower are the most important? Give reasons for your answer.

## HOW SEEDS ARE FORMED

You have already learned that the chief purpose of every flower is the production of seed. Before seed can be formed, *pollination* must take place. *Pollination is the transfer of pollen from the anther to the stigma.* How is this transfer accomplished? The story of pollination shows how

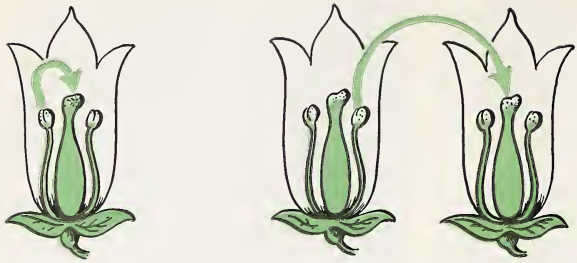


Diagram illustrating two types of pollination. Which is cross-pollination? Which is self-pollination? How is the pollen transferred from stamens to pistils? How are some flowers fitted to assist in cross-pollination?

wonderfully flowers are fitted to bring about successfully the transfer of pollen from anther to stigma.

Some flowers, such as those of wheat, oats, and a number of other plants, are *self-pollinated*. This means that the flowers are so constructed that the pollen is usually transferred from the anther to the stigma of the same flower.

Many flowers, however, are especially adapted to encourage *cross-pollination*, that is, the transfer of pollen from the anther of one flower to the stigma of another. In most cases, cross-pollination produces better offspring than does self-pollination. The two chief agents in transferring pollen are insects and the wind.

### How do insects carry pollen from flower to flower?

When watching bees flitting from flower to flower, have you noticed their hairy jackets heavily covered with pollen? When a bee, or another insect, crawls into the very lowest part of a flower, it rubs against the stamens and is showered with pollen. A moment later it enters another flower, and some of the pollen from its jacket is dusted on to the stigma of the pistil in the second flower, thus bringing about cross-pollination. The bee, therefore, renders a valuable service to the plant.

### Why do insects visit flowers?

The pupils in Miss Peterson's class had been observing bees and other insects on garden flowers. They learned that some flowers depend entirely upon insects to transfer their pollen.

Pollen grains, very highly magnified. These tiny bodies have many different shapes. Where is pollen produced? What purpose does pollen serve in the formation of seeds?

Now the class were discussing the means by which insects were attracted to flowers. Howard Kovacs mentioned color. Edith Hopkins suggested perfume. The other pupils agreed with these suggestions. However, Elaine Scott maintained that there was something more important. "The insects are searching for food," she said.

Elaine was right. Many insects depend for their livelihood upon the flowers they visit. Though insects are attracted to a flower by its bright color and pleasing perfume, something more than beauty is required to satisfy the needs of the insects and cause them to make repeated calls on the same kind of flower. The flower provides a rich reward of *food* for insects that serve it by distributing its pollen. What insect food does the plant provide? You will find your answer to this question by examining flowers according to the following suggestions:

Certain insects like nasturtium flowers. Why? How is a nasturtium flower adapted to ensure cross-pollination by insects?

#### SOMETHING TO DO

1. Discover for yourself how a nasturtium flower is adapted for pollination by insects. Secure several specimens of single nasturtiums. Examine them carefully. Find the *calyx*. Notice the long *spur*. Bite off the tip of the spur, and taste the fluid contained in it. This sweet fluid is *nectar*. Why does a flower produce nectar and store it in the bottom of a specially constructed part?

The brightly colored petals of the nasturtium are very interesting. Notice the dark lines on the upper three petals of the nasturtium flower. What purpose is served by these dark-colored lines? Why is the route to the nectar so well marked? Observe that the three lower petals form a good "landing field" for insects. Find the hairy fringe at the base of these petals. It serves as a barrier to keep out insects that are too small to help to pollinate the blossom. Why is it an advantage to the nasturtium not to feed these smaller insects?

Locate the parts of the pistil. Touch the stigmas of several flowers. Are they sticky? Why? Examine one or two stigmas under a magnifying glass. What do you see on the stigmas? From where did this pollen come? What is the most important function of the pistil? Into how many parts is the stigma divided? How many compartments are there in the ovary? What do you find in each compartment? These small white bodies are the ovules. If the flower is rather old, you may see that some or all of the ovules are changing into seeds. How does the pistil

Many kinds of trees have two kinds of flowers — one kind with no stamens, the other kind with no pistils. Left: Stamen flowers of the Manitoba maple. Centre: Stamen flowers or catkins of the trembling aspen or white poplar. Right: Pistil flowers of the aspen.[1]

Partially opened flowers of the white spruce. Some flowers of the spruce have pistils and no stamens. These are shown in the illustration. Other spruce flowers have stamens only.

of the nasturtium flower differ from that of the flower of the sweet pea? How many stamens do you find? Is there pollen on the anthers of the flower that you are examining?

Make a page of labelled drawings of a nasturtium flower, including (1) the complete flower, (2) an upper petal, (3) a lower petal, (4) a stamen, (5) the pistil.

2. Examine other common flowers, such as the pansy, snapdragon, petunia, and honeysuckle, to see how they are adapted for insect-pollination. Here are three problems for you to solve:

(*a*) Observe a bee pushing into a snapdragon. Use a finger to open a snapdragon as a bee would if entering it. Why can snapdragons be pollinated only by large bees?

[1]The illustrations on this page are from *Native Trees of Canada*, published by the Forestry Branch, Department of Northern Affairs and National Resources, and obtainable from the Queen's Printer, Ottawa.

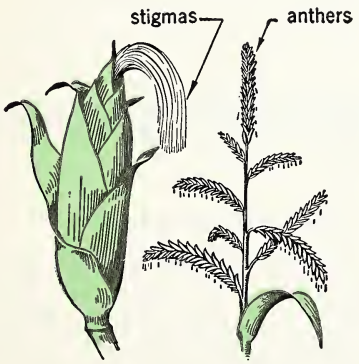
(*b*) Honeysuckles are chiefly pollinated by butterflies and moths, which are long-tongued insects. Explain why this is so.

(*c*) Find the nectar spur on a pansy flower. What part forms it?

3. Find out by observation which flowers are being visited by bees and which by butterflies and moths; then examine the structure of the flowers to discover the reason.

### Many flowers are wind-pollinated

Wind-pollinated flowers are lacking in color, scent, and nectar, and are seldom visited by insects. The flowers of willow, poplar, and maple trees are wind-pollinated. They produce an abundant supply of light pollen and have broad, feathery stigmas. Why? Examine these flowers in the spring. Have you noticed that the trees that produce them are in flower before their leaves are unfolded? Why is it an advantage for these wind-pollinated flowers to open before the leaves unfold?




Corn has two kinds of flowers. Pistil flowers are in the cob. Stamen flowers are in the tassel.

Corn plants, also, are wind-pollinated. Examine some corn plants in the fall to see whether their flowers are adapted for wind-pollination in the same way as are the flowers of the willow, the poplar, and the maple. Notice also that corn has two kinds of flowers on the same plant. One kind, in the *tassel*, has stamens but no pistils. You can easily find the dried-up stamens in the dead tassels, even in the fall. The other kind, in the *cob*, has pistils but no stamens. Each strand of the long "silk" on an ear of corn is a pistil. What is the work of each kind of corn flower? Is corn self-pollinated or cross-pollinated?

### Fertilization

Pollination is only the first step in the production of seed. After the stigma receives pollen, a wonderful process takes place. When a pollen grain becomes caught on the stigma, it sprouts and sends a very fine *pollen tube* down through the style to an ovule in the ovary. At the tip of the pollen tube is a tiny speck of life called a *sperm cell*. In the ovule is another tiny speck of life called an *egg cell*. The sperm cell finds its way to the egg cell, and the two unite. This union of a sperm cell with an egg cell is known as *fertilization*.

Thus fertilized, the egg cell develops into a *little plant* inside the ovule. The ovule growing into a mature *seed* still contains this tiny plant, through which, when the seed

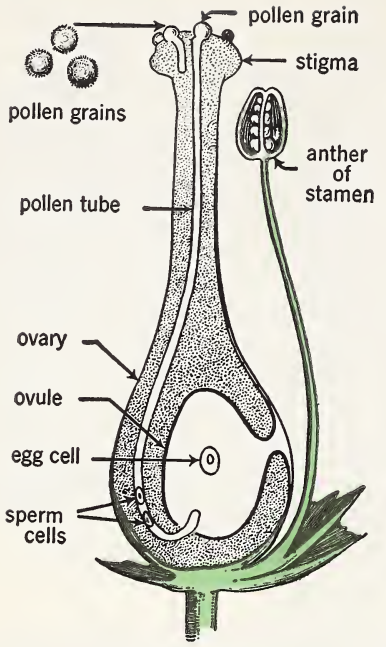



Diagram to illustrate fertilization in a common flower. When a sperm cell unites with an egg cell, a new plant develops. What determines the characteristics of this new plant?

is planted, the life of its kind is continued.

The *characteristics of the new plants* result as follows: The egg cell carries the characteristics of the plant on which it was produced. The sperm cell bears the characteristics of the plant from which it came. When the egg cell and the sperm cell unite during fertilization, the characteristics of *both* parents are passed on to the new plant that develops.

As an example of how characteristics are passed on to new plants, let us think of two aster plants, one of a variety with large flowers but susceptible to disease, the other of a variety with small flowers and resistant to disease. If cross-pollination and fertilization were to take place between these two asters, their characteristics would be passed on to the offspring somewhat as follows:

— Large flowers, susceptible to disease.
— Large flowers, resistant to disease.
— Small flowers, susceptible to disease.
— Small flowers, resistant to disease.

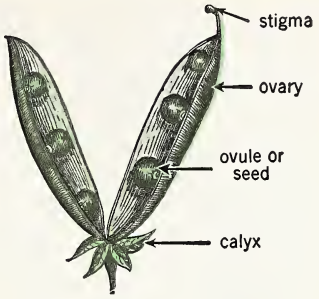
In some of the new plants, as you will see, the good characteristics of one parent plant would be combined with good characteristics of the other parent plant. The result would be a new aster, better than either of the parents. You will note, too, that some of the offspring have the poor characteristics of the parent plants.

#### SOMETHING TO DO

Learn by observation or experiment that ovules become seeds. Examine from day to day, the pistils of sweet peas, nasturtiums, delphiniums, hollyhocks, peas, beans, radishes, and other flowers. Watch the ovules as they develop into seeds. Does the ovary of the pistil change also?

### How are fruits formed?

Fertilization leads not only to the development of the seed but also to growth in the ovary and often in other parts of the flower as well. The final result of fertilization is the formation of a fruit. *A fruit is composed of the parts of a flower that do not wither*




The pod with the enclosed seeds is the fruit of the pea plant. Which part of the flower forms the pod? Which forms the seed? The fruit serves the plant in two ways: it protects the developing seeds, and it aids in the scattering of the seeds.

*but continue to grow after fertilization.* For example, the fleshy parts of the peach, plum, cherry, and tomato are the walls of the ovary. The fleshy parts of pears and apples are the swollen ends of the flower stalks.

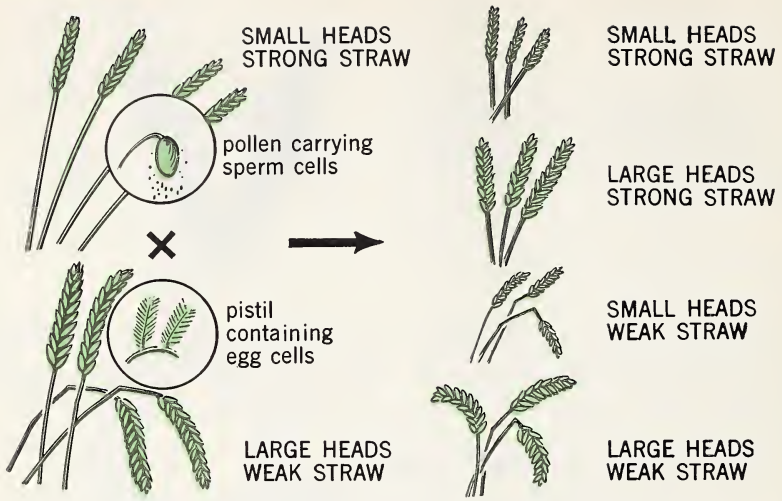
**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

1. Define pollination, self-pollination, and cross-pollination.
2. What service do flowers render to insects?
3. How is a corn plant adapted for wind-pollination? Name three plants that are wind-pollinated.
4. Tell in your own words the story of fertilization.
5. An experiment with red clover revealed that, from 100 heads of this plant visited by bumble-bees, 2700 seeds were obtained, but that from the same number of heads protected from the visits of these insects *not one seed* was obtained. What does this prove? Why were two groups of plants used in this experiment?

## HOW CAN NEW VARIETIES OF PLANTS BE PRODUCED?

Now that you know how seeds and new plants develop, you will readily see that to produce new varieties it was necessary to find an artificial means of transferring pollen from one plant to another. This feat was soon accomplished. Many new varieties of grains, fruits, and decorative plants have since been produced by artificial cross-pollination or *crossing* as the process is called.

As you have learned, the characteristics of the offspring come from the parents. Therefore, the plant breeder selects parent plants with the characteristics desired. He then produces seed by crossing them — that is, by taking pollen from the stamens of a flower on one plant and placing it on




When two plants are cross-pollinated (left), some of the offspring (right) will have the good qualities of their parents; others of the new plants will have the poor characteristics of the parent plants. The problem of the plant scientist is to study the new plants and select those with the good characteristics he wishes. Which of the new plants in this illustration would you select?

the pistil of a flower of the other plant. From the seed will grow new plants with characteristics of the parents. Some of the offspring will possess the poor qualities of the parents, and will be discarded. Others of the offspring will have the good characteristics of the parents and will be used to produce more seeds as the basis of future crops.

In the following sections, wheat has been used as our example for two reasons: (1) It is Canada's most important farm crop, and the chief crop we export to help feed people in other parts of the world. (2) It is an excellent example of the long scientific processes of plant improvement.

**How scientists solved the wheat-rust problem**

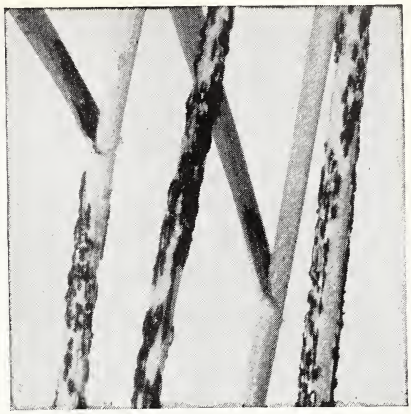
One of the chief reasons why scientists have sought to develop new varieties of crops was the desire to produce varieties that were capable of resisting certain disease such as *wheat rust* (a *fungus* disease) that were causing widespread damage and tremendous losses year after year.

For twenty years or more, the variety of hard spring wheat that was grown most widely in Canada and the United States was the one called Marquis. It yielded well, ripened early, made excellent flour, and had many other good qualities. However,

Marquis unfortunately had one great weakness: to a greater extent than most varieties, it was subject to the plant disease commonly called "wheat stem rust." Rust is spread by *spores* from wheat plant to wheat plant in much the same way as colds are spread by germs from person to person.

Many a year, the wheat gave promise of a "bumper" crop, only to have the yield reduced to a few bushels of shrunken, miserable-looking seeds per acre. It was little wonder that the farmers were often discouraged.

Scientists throughout Canada and the United States took up the challenge of beating the wheat-rust plague. The Canadian government established the Dominion Plant Disease Laboratory at Winnipeg especially to deal with this and other plant disease problems. Universities, experimental stations, and agricultural colleges all joined the fight against the wheat-rust fungus. Hundreds of thousands of experiments were performed over a period of about twelve years. Their efforts bore fruit in the development of several varieties of wheat that promised to be rust-resistant, including Thatcher, Apex, Renown, Regent, Selkirk, and others.



Three heavily rusted stems of wheat and one that is not rusted. Which stem is not infected? (Photo by W. E. Clark, courtesy Plant Pathology Laboratory, Winnipeg)

### The story of Selkirk wheat

During the years 1953 to 1955, a new variety called Selkirk was being hailed as a "wonder" wheat. It was resistant to all forms of rust, including the dread 15B rust, that were likely to cause damage to the wheat crop.

The pupils in Miss Peterson's class decided that it would be interesting and worthwhile to know how Selkirk wheat was developed.

Miss Peterson told the class that she had a government pamphlet containing information about Selkirk wheat and she would be glad to make this available to them. Tom Blair, who lived on a farm, remembered hearing his father talking about Selkirk. Tom volunteered to find out what his father could tell them about this new wheat. A third pupil agreed to write for information.

For several weeks the class gathered many facts about Selkirk, the new wheat that was to mean so much to the farmers. They compared the information received from various

sources. Finally, an accurate report was prepared as follows:

In the year 1930, wheat rust damaged crops over large areas. In the fall of that year, Mr. Malcolm McMurachy, a farmer of Strathclair, Manitoba, was threshing his rusted crop. He noticed two stems of wheat free from rust. Realizing the great possibilities of his discovery, Mr. McMurachy saved the seeds. By sowing seed each year and harvesting the crop, he multiplied his supply. By 1935, he had sufficient seed to sow six acres. In that year, too, the crop in Manitoba was so badly rusted that it was hardly worth harvesting. However, a wonderful thing happened on Mr. McMurachy's six acres — the crop grew strong and full, and *was almost entirely free of rust.*

Mr. McMurachy gave a small quantity of his precious seed to plant breeders at Brandon, Winnipeg, and Ottawa. Tests showed that the McMurachy wheat, as it became known, was highly resistant to the kinds of rust known at that time. However, it was low in baking quality — that is, it could not be used to make good bread.

In 1939, McMurachy wheat was crossed with a variety called Exchange. The purpose was to combine the high stem-rust resistance of McMurachy wheat with the high leaf-rust resistance of Exchange. This cross was the first of a number made at the Dominion Plant Breeding Laboratory in Winnipeg and from which Selkirk wheat finally resulted.

Seed from the first cross was harvested and planted to produce more seed. This was continued for several years. Each year, the seed was gathered from only the most promising plants. The others were discarded. Finally, a variety called R.L. 2265 was developed. R.L. 2265 possessed resistance to both stem and leaf rust, but had poor baking quality.

In 1944, R.L. 2265 was crossed with Redman wheat to improve its baking qualities.

In 1945, the best plants grown from seed from the R.L. 2265-Redman cross were selected and again crossed with Redman to further improve quality.

In 1946, the most promising plants were once more selected and crossed with Redman for the third time.

To hurry the work, crops were grown both in the greenhouse during the winter and in the field during the summer.

Over the years until 1955, the process of selecting the most promising plants, sowing the seed, and again selecting the best plants, was continued. Tests were made in twenty-three places in Western Canada. It became evident that a new variety, with good rust resistance and bread-making qualities, had been produced. It was named C.T. 186.

In 1952, when an epidemic of 15B rust threatened, the Dominion Department of Agriculture undertook to increase the supply of the new C.T. 186 by growing a crop during the winter on 150 acres in California.

Plant scientists cross-pollinate wheat varieties to produce new rust-resistant varieties for the wheat farmers. Why must the work of producing new rust-resistant varieties be carried on continuously? (University of Saskatchewan photo)

In 1953, further testing was carried out, and the amount of seed increased to 100,000 bushels. The name C.T. 186 was changed to Selkirk.

In 1954, seed of the new Selkirk wheat was made available to many farmers in Western Canada to help them fight the enemy 15B rust.

Who were the plant scientists who produced the good Selkirk wheat which meant so much to the wheat farmers of the prairies? Dr. C. H. Goulden was the officer-in-charge of the Cereal Breeding Laboratory in Winnipeg when much of the work that resulted in Selkirk wheat was done. The actual crosses were made by Dr. R. L. Peterson. The later selections from which Selkirk was eventually developed were made by Dr. A. B. Campbell. Other men at other places gave assistance in the final stages. Two important things to remember about the development of Selkirk wheat are that (1) it required a great many years, and (2) a number of plant scientists and others worked together until success was achieved.

In 1954, the Dominion government made a presentation to Mr. McMurachy in recognition of his great contribution to the western farmer and to agriculture in Canada.

Unfortunately, new races of rust, which can attack Selkirk, have been detected in Canada. They are not yet

serious threats to the wheat crop, but they may be in years to come. However, the plant breeders are continuing their important work of crossing and selecting. They will be ready, when the need arises, to provide the farmers with wheat varieties that will be resistant to these new rusts.

### Maintaining good qualities by selection

Every good farmer and gardener practises a system of selection to maintain the good qualities of his crops.

A farmer, for example, carefully watches his growing crop. When he finds that it is particularly good in one or more places in the field, he marks those places. Then he harvests and threshes the crop in the marked areas separately, and uses it for seed the following season. The seed from the selected crop is usually better than that from the general crop, because the plants that produced it were superior plants.

An improved melon produced by cross-pollination and selection. (Harrow Experimental Station photo)

Similarly, if a gardener looks carefully, he can often find flowering plants that produce larger or more beautiful blooms, or vegetables that are superior because they yield more or have better quality. By saving the seed from these outstanding plants and sowing it in his garden the following year, he is more likely to have better flowers and vegetables than he would have had, had he not selected superior plants from which to save seed.

### How potatoes can be improved

Potatoes were in common use among the Indians of North America when Europeans first visited the continent. They were introduced into England by Sir Walter Raleigh in 1586. Today, potatoes are said to constitute one-fourth of the food supply of the English-speaking people of the world. The work of developing new and better varieties, more suitable for particular needs and conditions, is constantly being carried on. The characteristics most to be desired in potatoes are: quality for table use, high yield, early maturity, and freedom from disease. Irish Cobbler is a good variety for general use.

Potatoes can be improved by the same methods as wheat — artificial cross-pollination or hybridization, and selection. Can you explain how better varieties of potatoes could be developed by cross-pollination? The procedure is very similar to that followed in the case of wheat. The seeds of

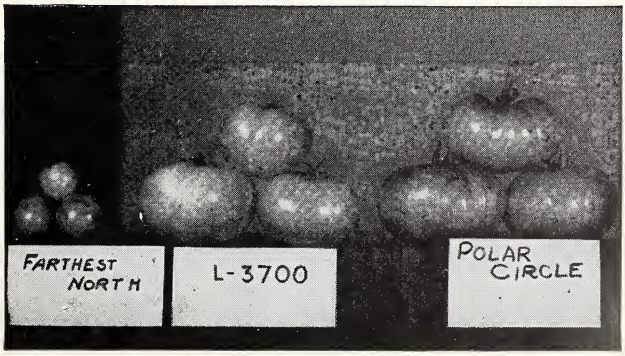
potatoes are produced in small, green, tomato-like fruits. Look for seeds in the tops of potato plants in the fall. Potatoes are not commonly grown from seeds. The usual method is to plant small potatoes, or pieces of larger potatoes. The buds or "eyes" develop into new potato plants.

Selection is the more common method of improving potatoes. During the summer, vigorous, healthy plants are marked by stakes. In the fall, these plants are dug by hand, and the number of potatoes produced by each plant is noted. The potatoes are saved from each plant that has produced a large number of good-sized potatoes. The following spring, these good potatoes are cut into pieces, each piece having at least one "eye," or bud, and the pieces from each potato are planted together in a short row. From each piece, a plant grows. During the growing season, the plants in each poor row are pulled up and thrown away. The potatoes produced from the remaining plants are used the following year for the main crop. Anyone who is growing potatoes may improve the quality and the yield of his crop by practising this system of selection.

### Better tomatoes

Most people enjoy eating tomatoes, especially the newer kinds, which have more solid fruit and fewer seeds

The Harrow tomato was produced at the Experimental Station at Harrow, Ontario. It is early, yields well, and does not crack. (Harrow Experimental Station photo)




A small, early variety of tomato, Farthest North, was crossed with Polar Circle, a large variety, to produce a new variety, L-3700. The L-3700 variety is much larger than Farthest North and almost as early. It will be a good variety for northern areas. (Lethbridge Experimental Station photo)

than previous types. At many experimental stations, earlier varieties with improved eating qualities have been developed. A good example is the Harrow tomato, a new variety in 1955, produced at the Harrow Experimental Farm in Ontario. This tomato ripens early, has good quality, yields well, and does not crack.

The tomato was originally a warm-climate plant. However, plant breeders have produced varieties that grow as far north as Alaska. The production of new varieties of tomatoes is a difficult undertaking and requires much knowledge of tomato varieties and characteristics.

Removing the tassels, or pollen-bearing flowers, from corn plants to produce hybrid corn. From where will pollen come to fertilize the flowers in the cobs of the detasselled plants? (See column at right.) (Pioneer Hi-Bred Corn Company photo)

**Hybrid corn**

Corn, too, has been greatly improved to produce varieties that yield well, ripen early, and bear large, well-filled ears or cobs.

Both yield and quality have been improved by growing *hybrid corn.* A hybrid plant is one that has been produced by cross-pollination.

In producing hybrid corn, two corn varieties with desirable characteristics are first selected. These are self-pollinated for several years, a process which tends to strengthen their good characteristics. Finally, these two parent varieties are planted as follows: a single row of one variety is planted with two to four rows of the other variety; the tassels, or pollen-bearing flowers, in the two to four rows are removed; the flowers in the cobs of these plants must then be pollinated by pollen from the tassels of the plants in the single row. This process of cross-pollination produces seed that will grow into a cross-bred or *hybrid* corn of high quality.

**Dr. Cyril H. Goulden — creator of new varieties**

Dr. Goulden, a Canadian plant scientist, has spent a large part of his life in the fight against plant diseases that have destroyed millions of dollars' worth of grain. He has helped to win the battle by creating new disease-resistant varieties that the "enemy" was powerless to attack.

Born in Bridgend, Wales, Dr. Goulden was brought to Canada at an

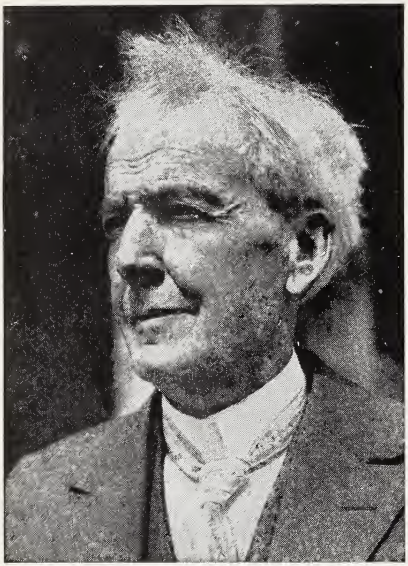
Left: Wheat growing in the "growth chamber" developed by Dr. Goulden to speed up the work of producing new varieties of grain. Right: Dr. C. H. Goulden, examining wheat heads in a field. (Left, Canadian Department of Agriculture photo; right, photo by Malak, Ottawa, courtesy Dominion Experimental Farms Branch)

early age by his parents, who settled on a farm near Yorkton, Saskatchewan. He thus grew up with first-hand knowledge of the damage caused by plant diseases. After many years of study and work with cereal diseases in Winnipeg and in Ottawa, Dr. Goulden was, in 1955, appointed the Director of the Dominion Experimental Farms, one of Canada's most important agricultural positions.

Dr. Goulden and his fellow workers produced such disease-resistant varieties of wheat as Redman, Regent, and the 15B rust-resistant Selkirk. Under his supervision, also, were created oat varieties such as Ajax, Exeter, Garry, and Vanguard.

One of Dr. Goulden's interesting and valuable contributions to the work of breeding new disease-resistant varieties is a "growth chamber." This is an apparatus for testing five generations of a new strain of grain in one year. With such equipment, the plant breeder is much better prepared to keep ahead of Nature's rapid production of new races of diseases.

Many honors have come to Dr. Goulden because of his work as a plant breeder. It has been said that "his name is indeed *golden* in the ears of the prairie farmers, because he makes two stems of wheat grow where previously one had sickened and remained barren." His work has benefited not only the farmers of the prairies but agriculture in all of Canada and the rest of the world.



Luther Burbank produced a very great number of new varieties of plants to add to the beauty and the food supply of the world. (W. Atlee Burpee Co. photo)

**Luther Burbank — the wizard of the plant kingdom**

Luther Burbank, an American plant scientist, gave the world many new varieties of plants. Throughout his life, he showed in many ways his great love for flowers, trees, and birds.

While still a boy, he discovered a particularly promising potato plant. The plant bore a single seed ball, which fell to the ground and was almost lost. But Burbank found it and from it produced the famous Burbank potato.

Later, he established a nursery business, which proved to be very successful, largely because he made it a hard and fast rule never to send out plants that were not exactly what they were represented to be. Finally, he decided to devote all his time to improving plants. On his large estate in California, he carried on his experiments, producing many new varieties of plants and proving their worth before he gave them to the world.

Burbank experimented in crossing a small but hardy American daisy, a large and vigorous daisy from England, and a Japanese daisy of dazzling whiteness and beauty. The final result was the large Shasta daisy, pure white in color and very beautiful.

Another of Burbank's famous experiments was performed on a cactus bristling with thorns that tore the flesh of man and beast. Without destroying its ability to grow in dry desert locations, he changed the cactus from an enemy into a friend — thornless, and useful as feed for cattle in dry seasons.

Before he died in 1926, Burbank was known throughout the world as the producer of more new forms of plant life than any other man. Some of Burbank's new plants were varieties of nuts, fruits, and vegetables, which added much to the food supply and wealth of the world. Others were flowers of great beauty and fragrance.

**SOMETHING TO DO**

1. New varieties of grains, flowering plants, fruits, and vegetables are continually being produced and recommended to farmers and gardeners. Some prove unsatisfactory. Others are found to be valuable and useful. *To keep up-to-date in the matter of new varieties*

*you should* (1) *read the newspapers and farm magazines,* (2) *watch seed catalogues for new plants introduced,* (3) *ask farmers and gardeners about new varieties.*

Bring to the attention of your teacher and classmates the information that you find. Cut out important items and keep them in a scrap-book on new varieties.

2. Visit flower and vegetable gardens. Ask to be shown new varieties of plants. Secure seeds of these plants for your own garden.

3. Follow some of the suggestions outlined in this chapter when you are gathering your potatoes to plant for next year's crop.

Carry out the suggestions, too, in regard to selecting seed from superior garden and grain crops to sow in your garden or plot next year.

High quality wheat from the farms of Canada helps to feed the people of the world. (Massey-Harris-Ferguson photo)

4. Compare the work of Luther Burbank with that of other scientists, for example Michael Faraday, in respect to its contribution to the world.

5. Mention some contributions that Canadian scientists have made to the improvement of plants.

**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

1. Explain carefully how improved varieties of plants may be developed by crossing. From where do the characteristics of the new plants come?

2. Why is a long system of careful selection necessary before a new variety becomes satisfactory?

3. How may a farmer or gardener maintain the good qualities of existing varieties by selection? Use as your example in answering this question *one* of the following: wheat, potatoes, tomatoes, or corn.

4. Why is a continual search for new varieties of wheat, potatoes, corn, and other crops necessary?

5. Where and by whom was Selkirk wheat developed?

6. The following diagram briefly shows how Selkirk wheat was developed. Explain the diagram in your own words.

McMurachy wheat X Exchange wheat

R.L. 2265 X Redman wheat

Selkirk (C.T. 186)

## WHEAT—CANADA'S MOST IMPORTANT FARM CROP

The Selkirk settlers (1812) were the first to sow wheat in Western Canada. Today it is the most important product of our prairie farms. It is one of Canada's chief sources of wealth. When the wheat crop fails, many classes of people experience "hard times."

For many years, the world championships in wheat, awarded annually at the great grain shows at Toronto and Chicago, have been won chiefly by Canadian farmers. Over a long period of time, the hard wheat of the West had been judged to be the finest in quality. However, in 1954, the championship at Toronto went to an Ontario farmer who exhibited a sample of eastern fall wheat.

The climate of Western Canada is especially suitable for producing wheat with excellent bread-making qualities. The millers of many other countries like to mix it with their own wheat, because the flour produced makes better bread than the flour made from their wheat alone. In Ontario, winter varieties of wheat are grown. These are valuable for producing pastry flours. Canada now leads the world in the export of wheat.

### The structure of the wheat plant

Wheat did not always produce large, heavy heads and high yields. Scientists, known as plant breeders, have done much to improve wheat since man first began to cultivate it. Some plants that have been developed have such heavy heads that the stems are not always strong enough to hold them up. Most wheat stems, however, are adapted by structure to produce heavy crops. By examining wheat plants, we shall learn why this is so.

#### HOW TO MAKE THE BEST USE OF THIS BOOK

Throughout the book, the various topics are presented in two parts: (1) suggestions about an experiment or an investigation, and (2) a discussion of facts about the topic.

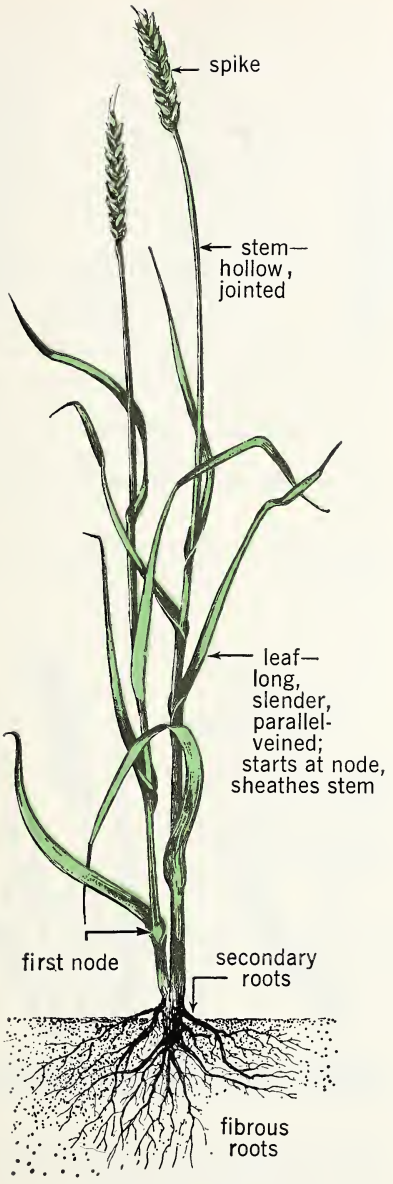
Be sure always to proceed as follows:

1. Conduct the investigation or experiment.
2. Think about your observations, and form your own ideas.
3. Consult the text to check your discoveries and perhaps to learn more about the subject.

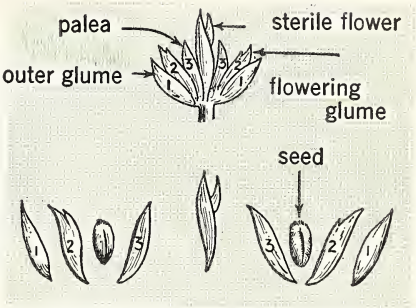
#### SOMETHING TO DO

1. Gather specimens of wheat. In digging up the roots, try to get as perfect specimens as possible.

Note. — Your observations may be made in the spring as the wheat is growing. You must look for wheat flowers early in July, or you will miss them. Keep a record in your science note-book of what you observe. If it is more convenient, plants may be stored for winter study. Tie a number into a compact




A typical wheat plant.




A spikelet of wheat. Above: Complete. Below: The parts separated.

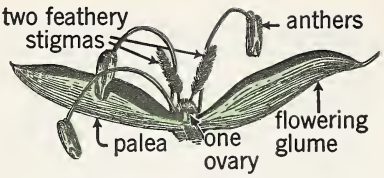
sheaf, and keep them where they will be protected from mice. Be sure to store specimens of roots, also. Wheat flowers can be stored in a 4-per-cent solution of formalin (4 parts of formalin to 96 parts of water).

Carefully examine your specimens of wheat plants and look for the following seven parts:

(*a*) The Stem. — What facts can you discover for yourself about the stem? Is it hollow throughout? Notice the *joints* or *nodes*. Are they hollow? Will they help to strengthen the stem?

(*b*) The Leaf. — Do you think that leaves of this shape offer much resistance to the wind? What advantage does this give to the wheat plant? How are the veins arranged? Will these leaves be easily torn by the wind? How is the lower part of the leaf arranged in relation to the stem? Might this help to prevent the stem from breaking?

(*c*) The Root. — Has wheat a tap (single) or a fibrous (many-branched) root? Can you distinguish two sets of roots? The upper set are called *prop roots*. What use can you suggest for prop roots?




A wheat flower (much enlarged). Each spikelet in a head of wheat consists of from three to five flowers.

(*d*) The Head. — A head of wheat is known as a *spike*. The groups of parts are *spikelets*. Observe that the spikelets are arranged alternately, back-to-back, along the stalk or *rachis*. This arrangement makes it possible to form strong, compact heads.

A *good head of wheat* is compact, free from disease, and well filled with kernels at the base and the tips as well as in the middle. Are the heads you are examining of this description?

(*e*) The Spikelet. — Dissect (take apart) a spikelet. Place the parts, as you separate them, on a piece of paper in the same order as you found them in the spikelet: *outer glume, flowering glume, seed, palea, sterile flower, palea, seed, flowering glume, and outer glume.* When the glumes become dry and yellow, they are called *chaff*.

(*f*) The Flower. — How many kernels do you find in a spikelet? Each seed is produced by one flower. In an average spikelet there are three flowers. The centre flower very frequently does not produce a seed; it is then called a *sterile flower*. The *fertile flowers*, which produce seed, have three stamens and one pistil (see the drawing above on this page). Wheat flowers do not last long. Watch for them early in July. They are small and green. When ripe, the yellow stamens hang out. Are wheat flowers wind-pollinated or insect-pollinated?

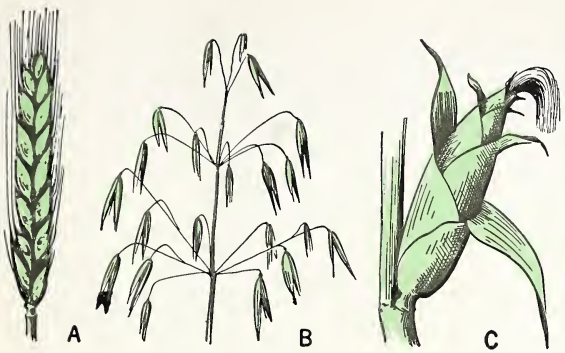
(*g*) The Seed. — Examine it with a magnifying glass if possible. Observe the tuft of fine hairs at the top. Notice that one side is creased. At the base of the seed is the *embryo* or *germ* (new plant). Is the germ on the creased side or the smooth side?

2. Make drawings to illustrate the parts of a wheat plant. As far as possible you should make your drawings from the wheat plant itself. Do not be satisfied with merely copying drawings made by someone else.

3. Make two drawings of a wheat kernel, one of the germ side and the other of the creased side. Name all the parts.

4. Draw an entire wheat plant. In drawing the base of the leaves, show

Left: Brome grass. Right: Timothy. These, as well as other grasses, are used to feed livestock to produce meat and milk.




Three useful members of the grass family of plants: A, barley; B, oats; C, corn.

clearly how they wrap around the stem. Label all parts of your drawing.

### Wheat — a member of the grass family

Wheat is a member of a very important family of plants, the *grass* family. A plant family is a group of plants having similar general characteristics. Members of the grass family include grasses, corn, the grains, and several other plants.

#### SOMETHING TO DO

You have already made a detailed study of wheat. Examine corn, barley, oats, several grasses, and other similar plants. Observe the stem, leaf, spikelet, and roots.

In what respects do these plants resemble wheat? In what respects do they differ from wheat? If possible, examine the flowers as well.

What other members of the grass family do you know?

#### TEST YOUR KNOWLEDGE AND UNDERSTANDING

1. Describe the root, stem, and leaf of the wheat plant.
2. What are the characteristics of a good head of wheat?
3. Describe a wheat flower. How many flowers are there usually in a spikelet?
4. By means of labelled drawings, describe a kernel of wheat.
5. What other plants are very similar to wheat? What is this group called? In what ways do they all resemble each other?

## HARVESTING THE WHEAT CROP

Up to 100 years ago, grain was cut by hand, and many men were required to harvest even a few acres a day. For centuries, the *sickle* or *reaping hook* was the common harvesting tool. With it, one man could reap

Cutting grain with the scythe (left) and with the cradle (right). Why was the cradle a better harvesting implement than the scythe? (International Harvester Company photos)

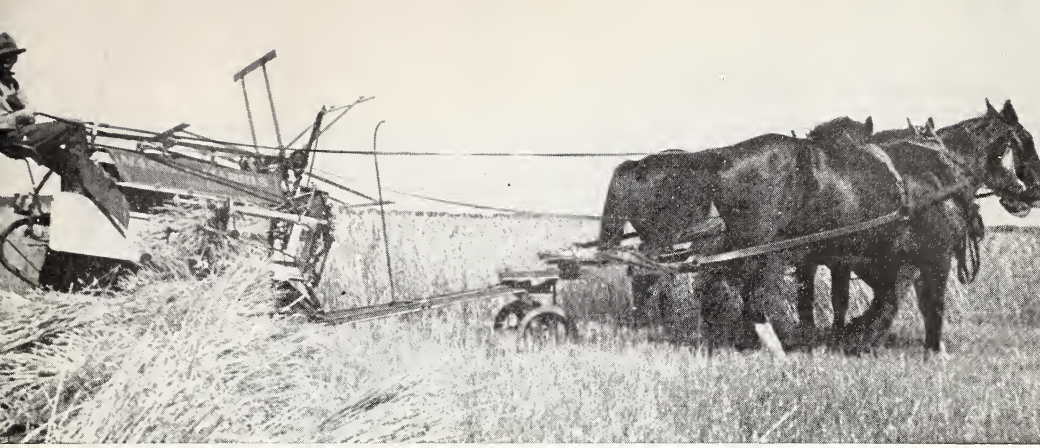
about half an acre in a day. The grain was tied into sheaves by hand. Harvesting by such methods was very hard work. Later, the *scythe* was used, and with it a strong man could cut two and a half or three acres of grain in a day.

As time passed, the scientist and the inventor made it possible for man to supply more wheat to more people. In 1831, Cyrus Hall McCormick, a young American farmer of Scottish-Irish ancestry, invented the *reaper,* a horse-drawn machine which cut the grain but did not bind it. Then came the *grain binder,* a remarkable machine that not only cut the grain, but also packed it into compact sheaves with the heads of grain all at one end, and bound each sheaf with a length of stout twine securely knotted. After the grain had been stooked and was ripe and hard, a *threshing machine* was pulled into the field, and the grain was threshed to separate the grain from the straw.

The modern machine for harvesting and threshing is the *combine,* which under certain conditions cuts and threshes the grain in one operation. A combine can cut from thirty to sixty acres in a single day.

The invention of machinery has done a great deal to remove the drudgery and hard work from farming. A century ago, each farmer was able to grow and harvest little more than enough grain for himself and his

The reaper, the ancestor of the binder. What was the advantage of the reaper over harvesting implements previously used? (International Harvester Company photo)



The binder cut the grain and tied it into sheaves held together by a circle of twine securely knotted. The binder and the threshing machine have been largely replaced by the combine. Even before the combine, tractors had almost entirely taken the place of horses as sources of power for binders and other farm machinery. (Massey-Harris-Ferguson photo)

family. Now, one farmer, with the help of modern machinery, produces food for many families with much less effort than formerly. Today we are producing more food per acre with less work and in less time than ever before.

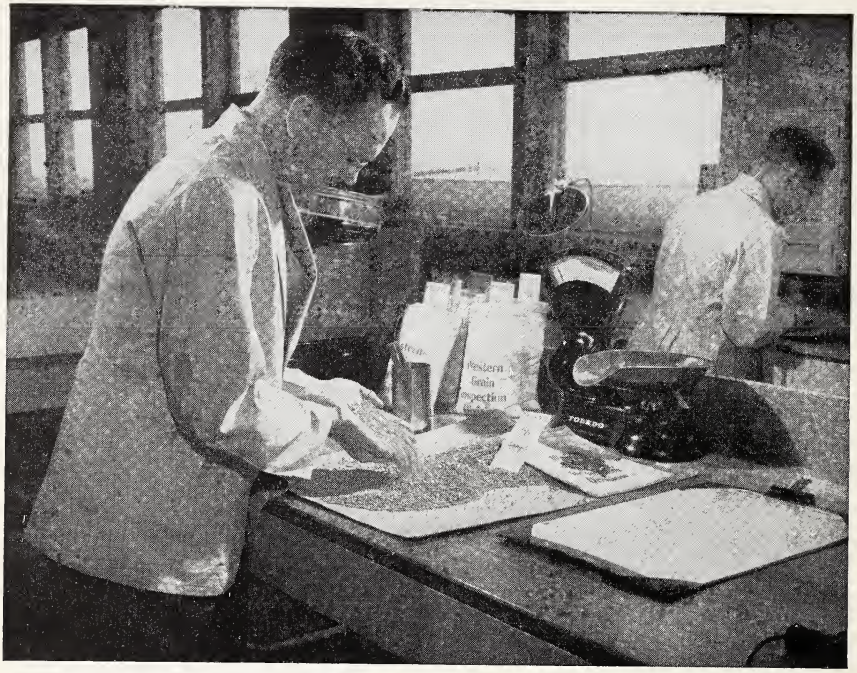
### Grading Canada's wheat crop

The grading of wheat and other grains is an important matter, because upon the grade given to his wheat depends the price received by the farmer. Each carload must be graded separately. The grading in Western Canada is done at Winnipeg, Regina, Calgary, and other cities in the Prairie Provinces, and at Vancouver and Prince Rupert in British Columbia.

When a carload of wheat arrives at a grading centre on the prairies, the seal on the door is broken and a government worker enters the car. He carries a long probe or sampler, with which he takes samples of wheat from various parts of the car. All the samples are emptied onto a canvas at the door and are thoroughly mixed. Then a small bag is filled with the mixture and taken into the grading room. If the car is to be shipped farther, the door is sealed again, and the car is sent to its destination.

The wheat in the small bag is then very carefully examined to determine its *variety*, to see whether its *color* is good, and to learn whether it has been *damaged* by frost or plant

The modern grain harvesting machine is the combine, which cuts and threshes the grain in one operation. Notice also the photograph on page 75. (Massey-Harris-Ferguson photo).



Grain inspectors test, examine, weigh, and record the grade of samples taken from western shipments of grain. (National Film Board photo)

diseases. A small amount is weighed to find its *weight per bushel.* Some of it is passed through sieves to measure the percentage of weed seeds in it. The weight of weed seeds in the carload from which the sample was taken is then determined, and is deducted from the total weight of the grain in the car. This is known as *dockage.* If necessary, some of the wheat is tested for moisture, because, to be good, grain must always be thoroughly dry.

There are a great many grades for the various kinds of grain. The Canadian grades of red spring wheat will serve as a good example. They are as follows:

*No. 1 Manitoba Hard.* — This is the best grade of wheat.

*No. 1 Manitoba Northern.* — This grade is defined as follows: 60 pounds per bushel; variety, Marquis or equal to Marquis; 65 per cent hard, bread-making wheat; well ripened and practically free from damaged kernels or other grains, free from chaff or other foreign material.

*No. 2, No. 3,* and *No. 4 Manitoba Northern.*

*No. 5* and *No. 6 Wheat.*

*Feed Wheat.*

On the certificate, along with the grade to which the wheat belongs, the class is given, with a note as to cause and condition; for example: *No. 2 Northern Smutty, No. 4 Northern Tough, Rejected No. 3 Northern Mixed Heated.* Sometimes there are *Special Grades* for badly rusted wheat.

All wheat infected with *smut* (a disease of cereal plants) is classed as *Smutty.*

All wheat that is badly mixed with other grains or with weed seeds that cannot be removed, or that is badly damaged, musty, sprouted, heated, or mixed with cinders or gravel, or that has an objectionable odor is classed as *Rejected.*

#### SOMETHING TO DO

1. Make a collection of samples of Canadian grades of red spring wheat or Ontario fall wheat for your school science museum.

2. Make a booklet of pictures, diagrams, and notes telling the story of the path of a carload of wheat from a farm

Crops, other than food crops, also have been greatly improved. These men are removing leaves of a tobacco crop from a kiln in which the leaves have been dried and cured. (National Film Board photo)

in Western Canada to a mill in Great Britain, or of another topic dealt with in this chapter.

3. Visit a grain field to watch a binder, combine, or threshing machine in action. Ask the operator to explain the operation of the machine to you. Find out the number of men required to harvest and deliver the grain to an elevator.

### TEST YOUR KNOWLEDGE AND UNDERSTANDING

1. Discuss the development of harvesting machinery from the sickle and the scythe to the combine of the present.
2. Do you think that modern machinery has helped to make the farmer's life more pleasant? How has it helped to reduce the cost of producing crops?
3. What procedure is followed in taking from a railway car a sample of grain for grading purposes?
4. Name the Canadian grades of red spring wheat. Define or describe the grade *No. 1 Manitoba Northern.*
5. What conditions cause wheat of various grades to be classed as *Tough* or *Rejected?*

## WHAT HAVE YOU LEARNED?

### IMPORTANT IDEAS AND UNDERSTANDINGS

A

1. The most important work of every plant is to produce more plants of the same kind.
2. Flowering plants accomplish reproduction largely by the production of seeds.
3. Each part of a flower is especially suited to perform its own particular work in the production of seeds.
4. Pollination is the transfer of pollen from the anther to the stigma within a flower or from one flower to another.
5. Fertilization is the union of a sperm cell with an egg cell.
6. When fertilized, the egg cell in the pistil of a flower develops into a tiny new plant within a seed.
7. Crossing is brought about by cross-pollination between two plants possessing the desired characteristics.
8. Following crossing, careful selection is necessary for several years in order to establish a new variety.

An airplane sprays a chemical on a grain crop to destroy weeds infesting the crop. This is an example of the many ways, in addition to crossing and selection, that man has developed to enable him to grow better crops. (Aviation Services photo)

9. Canada produces wheat of high quality.

10. Scientists and inventors have made it possible for man to supply more wheat for more people.

**(a) The foregoing sentences are all true statements of important science ideas and understandings. Read and discuss them carefully as a review of this chapter.**

**(b) The following sentences describe situations in which some of these ideas apply. To test your ability to apply ideas to actual situations, match the sentences in A with situations in B to which they apply.**

**B**

1. Anne Brooks and Marie Lucas saw some very attractive flowers. In order to grow some in their own garden, they gathered seeds to plant the following spring.

2. In a report he presented to his class, Ronald Shaw said, "In pioneer days, it took a large number of men many weeks to harvest and thresh the same crop of wheat that, with the aid of a modern combine, three or four men can harvest in ten days or less."

3. Mr. Goodman crossed a large double petunia with a small red one. In the next few years when he planted seeds from his new plants, he found several kinds — large, red; small, double; and so on. However, by carefully picking out plants with flowers that he liked, and using the seed from these plants for the next year's planting, he finally produced a new, large, red petunia.

4. The pupils in Miss Peterson's science class decided to watch a number of flowers. They saw the colored petals wilt and die. Other parts of the flowers also withered. However, the lower part of the pistil in each flower grew larger, and finally became a pod containing seeds.

5. The people in some countries cannot grow good wheat for making bread. They buy large quantities of Canadian wheat to mix with their own.

6. Roy Kendal was working in his garden. He observed many bees flying from flower to flower. They pushed deeply into each blossom. Several parts of their bodies were covered with fine yellow pollen.

## IMPORTANT SCIENCE TERMS

A

| | | |
|---|---|---|
| corolla | egg cell | cross-pollination |
| petal | sperm cell | self-pollination |
| stamen | variety | plant breeder |
| pistil | crossing | disease resistant |
| pollen | selection | weight per bushel |
| ovary | laboratory | No. 1 Manitoba Northern |
| ovule | dockage | grass family |

**To show that you understand and can use the science terms listed in A, match with the situations described in B those terms which apply.**

B

1. On his farm in Saskatchewan, John Thomson's father grows Selkirk wheat. When John visited his uncle in Ontario, he learned that his uncle grew Cornell wheat. Other farmers, John knew, grew Apex, Chinook, or Dawson's Golden Chaff.

2. Helen Smith and Rita Kusior were investigating color in flowers. They found that in most flowers, in our gardens, for example, the color is largely in one part. This part may be large or small and either a single color or a combination of colors.

3. In the spring, as the buds on the trees begin to open, the flower buds unfold first. When the flowers are in bloom, pollen is carried by wind or insects from flower to flower. This transfer of pollen is made easier because there are no leaves to interfere.

4. Jim Allison enjoyed his visit to a farm. One day, he went with Mr. McLeod while the latter delivered a load of wheat to the elevator. Walter was greatly interested in watching the man at the elevator as he graded the grain in Mr. McLeod's truck.

5. In a seed catalogue that Ralph Flaman brought to school, the pupils found a new variety of tomato described. It had been

developed from a variety of tomato that ripened early and another variety that grew well in dry districts.

**SCIENTIFIC METHOD AND ATTITUDES**

1. Alfalfa is an important crop for hay and soil improvement.

The pupils in Miss Peterson's class read a magazine article which emphasized the fact that seed production in alfalfa flowers is much greater when the flowers are visited by certain kinds of wild bees, such as the bumble-bee and the leaf-cutter bee. The article included a statement from an authority on insects.

Malcolm Gray immediately said, "I don't see how that can be true," and added, "It's not important anyway."

Gordon Wayne did not agree with Malcolm. "It may not be important to us," he said, "but it is important information for a farmer. I would like to know more about it." Gordon remembered the article, and some time later he found another account which gave him more information.

Which of these boys showed a scientific attitude? Why? State two characteristics of a person who has a scientific attitude, that might apply to this incident.

2. For the purpose of comparing four varieties of wheat, an experiment was conducted by a group of farmers in four different areas. Each farmer grew a small plot of each variety. The experiment was carried on for three years. Careful records were kept of:

It has been proved that certain kinds of wild bees, bumble-bees, and leaf-cutter bees increase seed production of alfalfa plants by helping to pollinate the alfalfa flowers. This is another example of the kind of knowledge that plant scientists are discovering by the scientific method, and which helps man to produce more food. Alfalfa is used to feed cattle to produce milk and meat. (Department of Agriculture photo, courtesy *The Country Guide*)

— The yield, in bushels per acre.
— The weight of a bushel of each variety.
— The grade of the crop from each plot.
— The number of days from seeding to ripening.
— The length and strength of straw.

The results were totalled, and the average was found for each variety in each area.

(*a*) Show clearly how the scientific method of solving problems was followed in this experiment. List the points.

(*b*) Assuming that milling and baking quality and resistance to disease are also important qualities of a good variety of wheat, would a farmer be justified, on the basis of this experiment alone, in reaching the conclusion that any one of the four varieties is the best one to grow? *Give a reason for your opinion,* keeping in mind your answer to question (*a*).

Wheat grown on the prairies of Western Canada is sold to many countries. This map shows the routes by which wheat is shipped to feed people in other parts of the world. Trace and explain each route. Follow the arrows. Would you think that some of these routes are better than others? Why?

J. Horace McFarland Co.

*If there are tongues in trees, and books in running brooks, so surely are flowers the teachers of happiness, joy, and peace.*

—*Selected*

CHAPTER 3

CHAPTER 3

# FALL ACTIVITIES WITH PLANTS

**In the summer when we see a garden in full bloom we do not always stop to realize the great amount of work that was done in the garden the previous autumn. What fall activities are necessary to ensure a good garden the following summer? How can we make a winter "blanket" for perennials? How can we have a window full of colorful bloom in January? Wild flowers and seed pods offer many opportunities for interesting fall observations and study. In what ways are seed pods specially adapted to scatter their seeds effectively?**

THE SAYING, "A THING worth doing is worth doing well," is surely true of a garden. All of us enjoy the beauty of a garden that is well cared for and in a thriving condition. On the other hand, a poorly kept garden is nothing but an eyesore. A wise gardener plans his garden carefully and makes many preparations well in advance of the time when he expects it to be in bloom. Some of these activities must be carried out as far ahead as the previous autumn. What are some of the preparations a gardener should make in the fall?

Miss Peterson opened the science class one morning by stating: "This would be a good time to do our fall gardening. Soon the ground will be frozen, and any outdoor work in the garden will be impossible." Whenever Miss Peterson made a statement such as this, the pupils knew that another interesting topic was to be introduced.

Not many of the pupils in the class could think of things that they should do to "put a garden to bed" for the winter. However, Joan Graham said she thought that gardens were important because they were sources of beauty and pleasure. Harold Parsons agreed with her and added that gardens also provided much of our food.

### The scientific method and scientific attitudes

Our study of plants will provide you with many opportunities to practise the scientific method. Review the discussion on pages 28 to 35. You will have opportunities to develop and strengthen scientific attitudes as outlined on pages 12 to 15. For example, you should be open-minded — that is, willing to change your ideas about what to eat as you find new information. You may need also to be careful not to jump to conclusions before you have accurate and complete information.

## FRESH GARDEN VEGETABLES FOR THE LONG WINTER

The problem of ensuring a good supply of fresh vegetables is greater in winter and spring than in summer and fall. However, the scientist has made important contributions to the solution of this problem. The plant

There are many varieties of flowering plants that are suitable for the garden. Petunias, such as those shown in the photograph at the right, are popular. Observe gardens in your locality to learn which kinds of flowers are commonly grown. Some flowers appear to stand more frost than others during the fall season. Observe some of these with a view to selecting a number of them for planting next summer in your garden. (Ferry-Morse Seed Co. photo)

In this attractive front garden area, plant growth is obviously over for the season. What work might have been done in this garden to promote good growing conditions next spring? (Rusco Windows photo)

scientist has developed improved varieties of vegetables which yield well and have good winter-keeping qualities. Other scientists have been successful in finding out how to can vegetables and how otherwise to keep them in good condition for winter use.

#### SOMETHING TO DO

1. Visit a vegetable garden. Help the gardener to harvest and store the vegetables for winter use.

2. Make a plan, drawn to scale, of an attractive garden. Show the location and arrangement of the flower-beds, lawns, garden furniture, trees and shrubs, and the chief varieties of flowers.

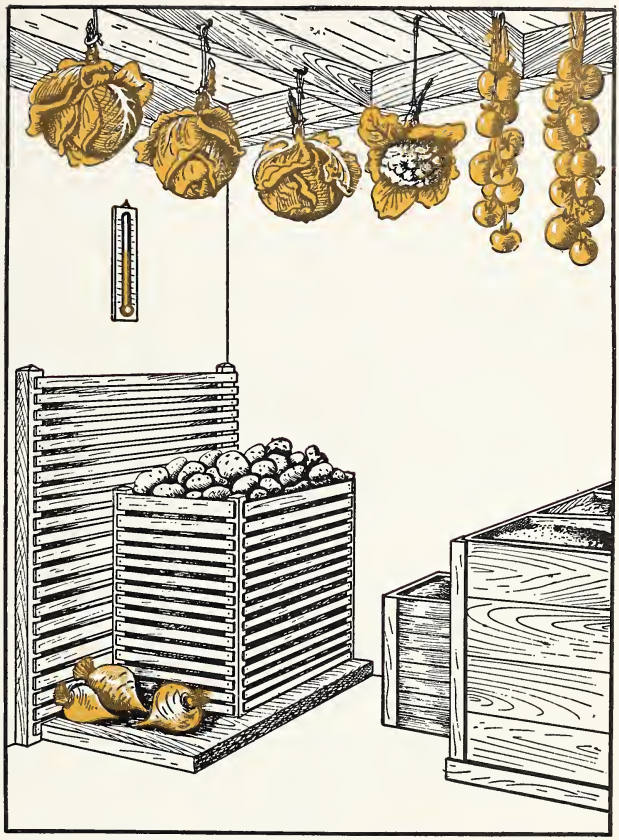
3. Gather flower seeds of mature plants to sow next year in your garden. Keep the different varieties in separate envelopes. Record on each packet the name, color, and height of the variety.

4. Take pictures of some especially interesting features of gardens that you visit. Mount prints of them in your science note-book.

5. Help to organize a "bee" to clean up your school grounds before winter sets in. Make plans for improvements. Decide upon and carry out work that should be done this fall.

### When and how should vegetables be harvested?

Miss Peterson's class went to see Mr. Brown's garden, which was not



This drawing illustrates a well-planned storage room. What provision has been made in this room to ensure the best possible storage conditions for the various kinds of vegetables?

far from the school. Mr. Brown, who was an expert gardener, was very pleased to have them come, and he told them many interesting things about harvesting and storing vegetables.

The proper time to harvest vegetables depends chiefly upon their maturity and upon the manner in which they are to be used.

Peas and beans should be gathered young and fresh.

Beets and carrots require thinning from time to time; some of them, therefore, should be pulled and used during the growing season and the rest should be harvested and stored before freeze-up.

Cabbage is ready for use as soon as it develops a large, solid head. Vegetables such as cabbages and turnips will stand some frost, but care must be taken to see that they are not exposed to heavy freezing.

Mr. Brown explained that only a part of the parsnip crop should be harvested in the fall; the rest of it should be left in the ground and dug up in the spring before there has been an opportunity for much growth to take place.

The pupils learned from Mr. Brown that tomatoes should be picked from the vines as they ripen; or, if they are late, they may be gathered green and ripened indoors.

Onions should be pulled when they are ripe, usually during the month of August. Before being stored for the winter they must be properly dried out, so that there will be no danger of their rotting. If the weather is dry and sunny, they may be left on the ground for a week or more until they are thoroughly cured. The tops should then be twisted off.

Mr. Brown was proud of his splendid potato crop. "Potatoes," he said, "should be dug in the fall after the tops are dead, unless danger of frost makes earlier digging advisable." The work should be done on a fine, dry day, so that very little soil will cling to the potatoes. Any soil remaining on them will shake off in the handling after a few minutes' drying in the sun and the wind.

Wet, muddy vegetables should never be put in a storage room, as they are likely to rot.

### Storing vegetables

As all of us know, to keep our bodies healthy we must include fresh vegetables in our diet all year round. Vegetables that are to be kept for use during the winter months are usually stored in the cellars of our homes. A suitable storage room for vegetables can be made by carrying out the following instructions:

1. Board off a suitable portion of the cellar.
2. Cover the partition both inside and out with felt paper to keep out the heat from the furnace.
3. Lay a false floor over part of the room, and nail slats to the walls around this floor.
4. Screw several hooks into the ceiling.
5. Provide a few slat boxes and old sacks.
6. Build a few bins on one side of the room.
7. Store some sand in one of the bins.
8. Hang a thermometer in the storage room.

The size of the room will depend on the size of the family and also on the space available. A good storage room must be dark and cool (a temperature of from 35 to 40 degrees is best); it must be well ventilated with moderately moist air, and protected from frost. Poor ventilation and excessive dampness favor the spread of disease and decay. On the other hand, if the air is exceedingly dry, too much moisture will evaporate from the vegetables, leaving them shrivelled and shrunken. Before placing vegetables in the storage room, care should be taken to see that they are sound, dry, and clean.

Potatoes should be piled on the false floor, against the slatted walls to ensure ventilation. Sort over the potatoes occasionally and remove sprouts and all decayed tubers.

Cabbages should be stripped of their outside leaves and hung by the stem end from hooks in the ceiling.

Carrots, beets, turnips, and parsnips are usually stored in sand to prevent them from becoming dry and soft. When boxes are used, a little damp sand should be placed in the bottom of the boxes, and on this should be laid alternate layers of vegetables and sand. To keep the sand slightly moist it may be necessary to add water from time to time.

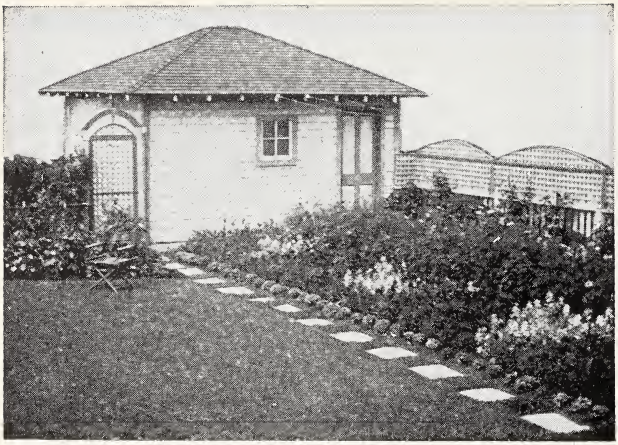
Onions, if they are dry and well cured, should be placed in slat boxes or shallow trays, and may be stored either in the storage room or in the attic.

Tomatoes may be treated in either of two ways: each fruit may be wrapped in paper, and left to ripen in a closed box in a warm room, or the vine may be pulled before there are any signs of frost, and suspended from the ceiling of a dark room in which the temperature is about 60 degrees.

The table below sums up the main points to be remembered in storing the various kinds of vegetables for the winter.

**STORAGE CHART**

| Vegetables | Best Temperature | Will Keep Until | Remarks |
|---|---|---|---|
| Beets | 33°–38° | May | Will keep best in sand. |
| Carrots | 33°–38° | May | Will keep best in sand. |
| Cabbage | 32°–37° | March | Provide good ventilation between heads. |
| Cauliflower | 33°–38° | December | Hang head downward. Do not allow heads to touch. |
| Onions | 35°–40° | May | Keep in shallow layers or shelves, trays, or slat boxes. |
| Parsnips | 33°–38° | May | Keep in slightly moist sand. Leave some in ground all winter. |
| Swede Turnips | 33°–38° | May | Keep fairly dry. Easy to store. |
| White Turnips | 33°–38° | April | Keep in sand or boxes. |
| Tomatoes | 50°–65° | December | Wrap individually in paper, or suspend vines from ceiling. |



What will have to be done to prepare this garden for winter?

**Making the garden ready for winter**

Perennials should have a place in most gardens. Usually they grow best when left undisturbed in one location. At times, however, it may be desirable to make changes.

Fall is the time to transplant certain perennials, such as peonies and iris, which you may wish to rearrange in your garden. Dahlia tubers, tuberous-rooted begonias, and gladioli corms should be kept in a cool, dark place. The tubers should be spread on a layer of slightly moist sand in the bottom of a box, and covered first with more sand, then with a layer of newspapers. Gladioli corms keep well if they are hung up in paper sacks in a cool place.

To reduce the danger of attack by harmful insects, the garden should be kept free of weeds in the fall.

All waste material, such as potato tops and sweet-pea vines, should be gathered up and removed. These tops may be used on perennial flower-beds to help to catch the snow; or they may be piled up with alternate layers of soil so that they will rot and form a supply of *compost*, or rich decayed vegetable material, to be used in place of manure to add fibre and plant material to the soil. Rotting will be hastened if the compost pile is kept compact and moist. To ensure an early start in the spring, the manure should be cleaned out of the hotbed.

Flower-beds of perennials should be covered with fine, well-rotted manure, which can often be used with advantage on lawns also. The covering should be applied just at freeze-up. The manure helps to hold a snow blanket over the plants and adds fertility to the soil. When the manure is raked off in the spring, the finer parts are left and should be dug in around the plants in your flower garden.

In localities where the land is heavy, the garden should be dug or ploughed in the fall and left in the rough all winter. The winter's frosts help to break up the clay lumps and make the soil friable and easy to prepare for early spring planting. A trench for sweet peas may also be dug in the fall.

Before the frost comes, a supply of rich, sandy loam should be taken indoors. It will be needed for planting winter bulbs, slips of house plants, and annual flower seeds. A sack of well-rotted manure and some sand will also be useful.

### A gardener knows where to dig for happiness

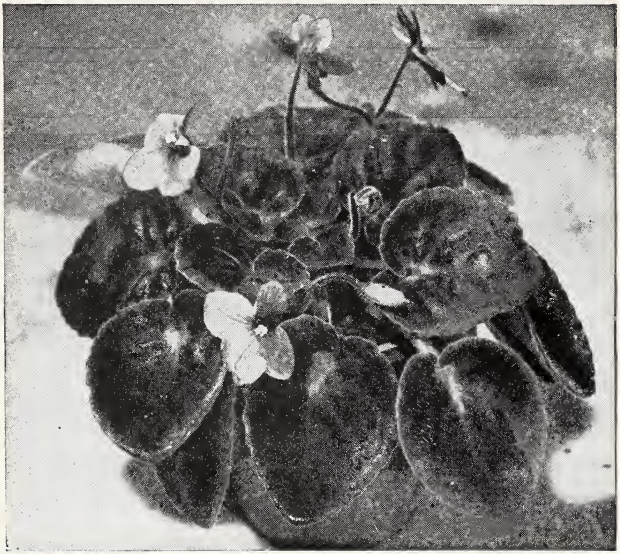
Many people go to the ends of the earth to find enjoyment, while others find it in their own back yards. A gardener finds his chief satisfaction in well-trimmed lawns, in colorful flower-beds, in graceful trees and shrubs, and in row upon row of healthy fruit and vegetables.

If you have never experienced the thrill of seeing plants you have tended and cared for grow into things of beauty or of practical use, plan this fall to give yourself that pleasure by having a garden next year. If you already have a garden, it is not too soon to consider improvements you can make in it. Spend some of your leisure time during the fall and winter months examining seed catalogues, nursery pamphlets, and gardening magazines to find suggestions for making or improving your garden.

The gardener's task is never finished; his practised eye can always find some way of obtaining better results. As every successful gardener knows, fall preparations are just as important and must be just as carefully carried out as spring garden work.

#### TEST YOUR KNOWLEDGE AND UNDERSTANDING

1. Give two good reasons why we should have flowers around our homes and at school.
2. What fall work is necessary to prepare the garden for winter and for early spring planting?
3. What precautions are necessary in harvesting the following vegetables: green peas, cabbages, onions, potatoes, tomatoes?
4. Why is each of the following conditions necessary to store vegetables satisfactorily for winter use: good ventilation, moderately moist air, and a cool temperature?
5. Write in your science note-book a description of a room that would be suitably equipped for storing vegetables.
6. Heavy garden soil should be dug or ploughed during the autumn. Why?
7. What is a compost pile? How does it help to conserve waste plant materials?



The African violet is a beautiful and easily grown house plant. Many enthusiastic African violet growers have organized themselves into clubs in order to promote their hobby. (Canadian Industries Ltd. photo)

## FLOWERS FOR THE SCHOOLROOM AND THE HOME

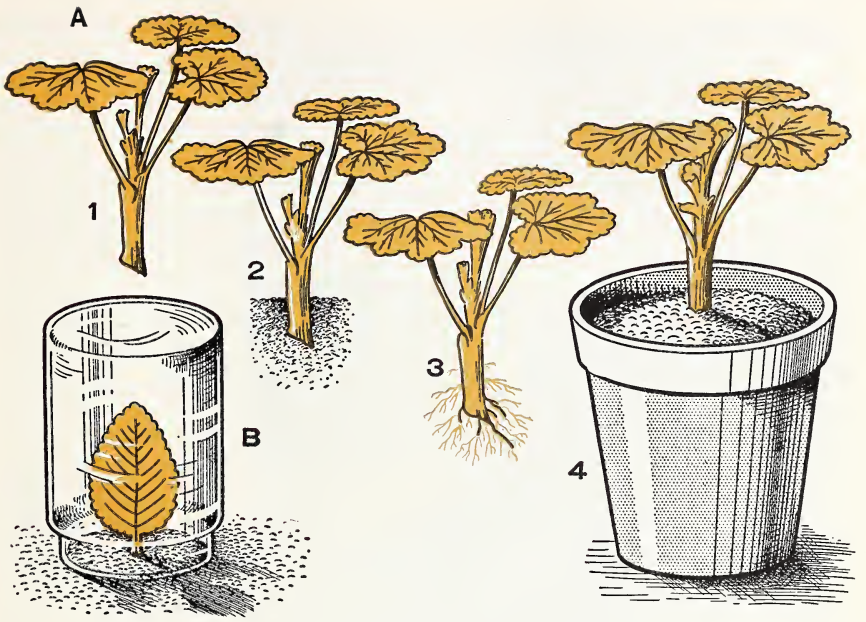
Anne Brooks was presenting a strong case for having some flowers in the classroom. "Almost one-half of the time we are awake," she said, "we spend in school. Then why not make our classroom as cheery and pleasant as possible by the addition of a few colorful geraniums or other suitable plants?" Some of the pupils asked, "Where would we get the plants?" Others said, "They'll freeze during the winter." But Howard Kovacs came enthusiastically to Anne's support. "We could bring plants from home," he said, "or start some from slips." "And we could take them home again when cold weather sets in," exclaimed George Smith, "if there is danger of their freezing at school."

### Start plants from slips

A few touches of natural beauty and color add charm to any room. Some attractive plants that may be grown from slips are: geraniums, foliage plants (coleus), begonias, Wandering Jew, African violet, ivy, and cacti.

#### SOMETHING TO DO

1. Select from one of these plants a vigorous shoot, about three or four inches in length, that has been growing rapidly. Cut it off where it joins the stem. If the shoots selected are longer than four inches, shorten them by making a slanted cut through them just below a *node* (the joint from which a leaf has grown). Remove some of the leaves — three or four are enough to




Many house plants are easily started from slips or cuttings. A: (1) A suitable geranium slip. (2) The slip placed in sand to start roots. (3) A well-rooted slip. (4) The rooted slip planted in good soil. B: Using a leaf to start a new African violet plant. It may be rooted in vermiculite, peat moss, sand, or water.

leave on it. Set the *slip* or *stem cutting* in water, and keep it in a light, moderately warm place. Add fresh water as it is needed. Do not expect roots too soon. But if, however, even after a few weeks roots have still not developed, it may help to plant the slip in soil that is fairly sandy.

Many slips may be rooted in clean sand or soil, or in vermiculite, which may be secured from a florist. Keep the sand moist but not saturated. It is a good plan, after the first few days, to allow the sand to become fairly dry before watering it again. This allows air to get in around the slip and helps to keep it in a healthy condition. At first it may be difficult to judge the amount of water your slips should have, but you will soon learn how much to give them.

Flower-pots, tin cans, or chalk boxes may be used for potting rooted slips. Bind chalk boxes with wire to prevent them from warping. Whatever type of container you use, it must have a hole or holes in the bottom. Carefully pile small stones or bits of crockery over the holes to ensure good drainage. Partly fill the container with fairly rich garden soil to which has been added a little fine sand. The soil should be moist but not wet. Then plant the slip with about two-

A well-rooted African violet leaf. In this case, the roots were developed by suspending the leaf so that the stalk dipped into water in a tumbler. (See also page 99.) The rooted leaf is now ready to be planted in good soil.

When the leaves of the new plant have developed as shown, the parent leaf may be removed.

Frequently, one leaf will produce several new plants. These should be separated and planted in individual small flowerpots. (Canadian Industries Limited photo)

thirds of the stem below the top of the container. Be sure to spread the roots out well. Press the soil lightly about the roots. The pressure to be used will depend on the dampness of the soil. It is better to leave the soil a little too loose than to pack it too hard. Fill the container with soil to within half an inch of the top. Finally, water the slip thoroughly. This will help the roots to establish themselves by packing the soil around them. Keep the slip out of the direct sunlight, but not in the dark, for a day or two. Then place it in a sunny window.

2. You can learn another way to start plants by using a leaf of an African violet. Select a healthy-appearing leaf. Place the stalk of the leaf deeply in vermiculite or sand. Keep moist. If the air is dry, a glass jar should be inverted over the leaf. The leaf stalk should take root and produce a new African violet plant.

3. A very decorative plant may be produced by placing the cut-end of a sweet potato in water. This is an easy way of developing a plant for your classroom.

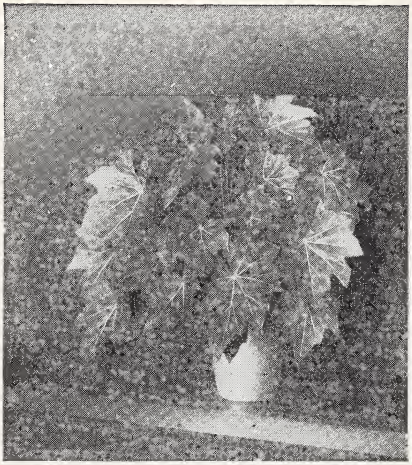
### How to care for house plants

Plants grow best in a temperature that is kept uniformly at 60 to 65 degrees Fahrenheit. As the temperature indoors is usually higher than this, you should set your house plants in the cooler part of the room, probably on the window sills.

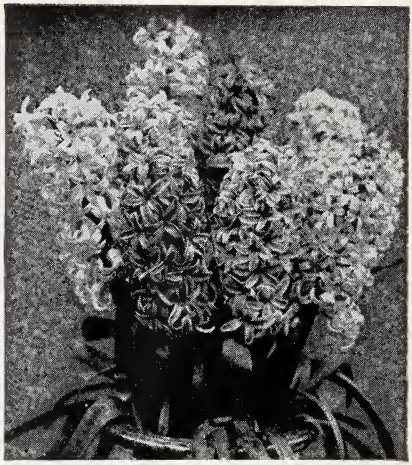
The air in which plants are to be grown must not only be cool; it must also be moist. There is no danger of having the atmosphere too moist, or humid, for plants. If your home or school is heated with hot air, keep the water pans in the furnace filled. If you have a hot-water heating system, hang on the radiators humidifiers or pans, from which water may evaporate. You may also increase the humidity by keeping a pan or kettle of water heating on the stove. Humid air is good for people as well as for plants.

Water your plants regularly and properly. The amount and the frequency of watering should be determined by the kind of plant, its leafiness, the sandiness of the soil, the temperature of the room, and the size and nature of the container. Examine your plants daily to see if the soil is dry. Give each plant enough water at one time to soak to the bottom of the container. The soil is moist to the bottom when the water runs out of the drainage holes into the saucer, provided it has not merely run down between the soil and the container. Let the soil become fairly dry between waterings. Too much and too frequent watering drives the air out of the soil, and the plant becomes unhealthy. Make sure that the container drains properly. Do not allow excess water to stand in a jardiniere or saucer. Use natural soft water if it is available. Stirring up the top soil now and then encourages healthy growth.

Wash the foliage occasionally with water to remove dust; when dust is allowed to accumulate, it interferes with the work of the leaves. Washing may be done with a fine hand spray



Begonias are attractive house plants that can be grown from leaf and stem cuttings. (W. McCowan photo)



A bowl of mixed hyacinths — King of Blues and Queen of Pinks. (Photo by Kenneth McDonald & Sons, Ottawa)

or with a sponge, but a better and easier method is to set the plant outside during a warm, gentle rain. This will improve both its appearance and its health.

All plants must have light, but they do not all require the same amount. In general, flowering plants need more light than foliage plants, and ferns require less. Set your flowering plants, therefore, in a window with a southern exposure, and your ferns in a west or north light. African violets prefer a north window. Turn the plants from day to day so that all parts of them may receive the light, and thus be enabled to grow erect and develop uniformly on all sides.

Insects bring death to house plants. Watch carefully for the appearance of plant lice or aphids, mealy bugs, and red spiders. Healthy plants are not so likely to become infested as sickly ones. Geraniums are seldom attacked by insect pests. If plants are washed regularly with soapy water, insect pests can usually be kept under control. Should aphids become a menace, spray your plants with a suitable chemical solution.

Note. — For washing plants, use one ounce of laundry soap to one quart of water. For a spray, use Black Leaf 40, which may be purchased from a florist. The spray should be diluted by adding water and must be applied directly on the insects. Mealy bugs must be washed off the plants; Black Leaf 40 or similar sprays will not destroy them.

Remove dead leaves and withered blooms regularly, and clear away

## A Bulb

*"I placed it in the earth — this bulb of mine —*
*And from its narrow prison house at night*
*It struggled forth to reach the air and light;*
*And as it rose and blossomed to the sight,*
*Its absolute perfection seemed divine!"*

*J. C. Ascher*

from the top of the soil all dead plant material and other rubbish. Such material attracts insects and is unsightly.

#### SOMETHING TO DO

To stimulate growth and bloom in your house plants, use Vitamin $B_1$. This preparation may be purchased from seed supply houses or from florists. Special plant fertilizers may be applied to the soil from time to time. *Be sure to follow the directions that come with the Vitamin $B_1$ and the plant fertilizers.* Failure to do so may lead to disappointing results.

### How to grow a bulb

For indoor cultivation, the common winter flowering bulbs, such as tulips, hyacinths, daffodils, and narcissi are best. They are a source of great beauty, and can be obtained in a large selection of colors. They thrive and produce lovely blooms under a wide range of conditions. Try growing some bulbs this winter. Use the directions given in the following paragraphs for planting and caring for them. By careful planning you can have a succession of bloom to brighten your schoolroom or your living-room at home throughout the cold winter months.

Tulips, daffodils (where the climate is suitable), and other bulbs may be grown outdoors. The bulbs are planted in the fall and provide a colorful early spring display. The soil should be worked up thoroughly to a depth of eight inches. The depth of planting should be about three times the diameter of the bulb.

#### SOMETHING TO DO

Secure a fall bulb catalogue from a reliable seed company or nursery, and make your selection of plants from it. For table and window display, tulips, hyacinths, daffodils, and Paperwhite narcissi are most commonly grown. In selecting tulips, choose the early varieties. They can be obtained in many shades. Of hyacinths, the Dutch is the best. As tulips, daffodils, and narcissi are cheaper than hyacinths, it might be well to experiment with them first.

Time of Potting. — Early tulips and Paperwhite narcissi should be planted in September or early October. You might plant some tulips, hyacinths, or daffodils about the first of October, a few more two weeks later, and so on until the

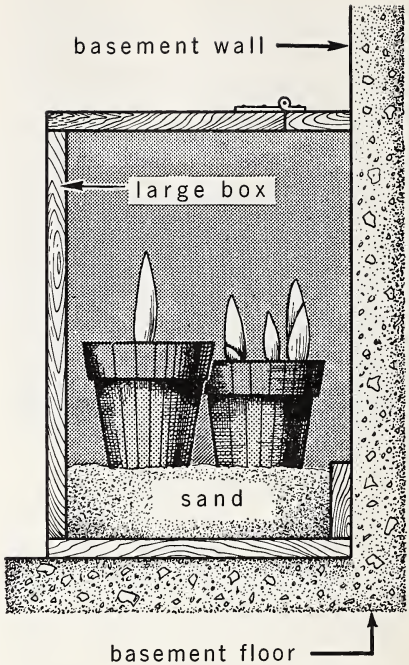
middle of December. This will provide for a succession of bloom throughout the winter. If you plan to grow only a few bulbs, pot them all early in October.

Containers. — Standard flower-pots are best, but you may use tin cans if you punch holes in the bottom to provide drainage. The size of the pot required depends on the size and the number of bulbs to be planted in it. Tulips may be planted singly in three-inch pots, or in groups of three in five-inch pots. Hyacinths and daffodils, being larger bulbs, require a little more space.

Soil. — Use a mixture of rich loam and sand in the proportion of three to one. You can increase its fertility, if necessary, by thoroughly mixing into it some leaf-mold, well-rotted manure, preferably cow manure (one part to three parts of soil), or bone meal (one teaspoonful to each pot).

Planting. — In planting, be very careful to place the bulb at the proper depth in the soil and to pack the soil lightly. Cover the drainage hole in the bottom of the pot with small stones or pieces of crockery. Put some soil into the pot, and pack it lightly. Add more soil. Continue this until by trial you find that, when the bulb is placed on top of the soil, its tip is as high as or higher than the top of the pot. Add more soil, leaving the tip of the bulb exposed above the surface. Finally, water the soil thoroughly to settle it and bring it into close contact with the bulb. Add more water from time to time to keep the soil moist.

Root Development. — In order to produce large blooms, *a bulb must develop a strong root system before shoot growth commences.* For root growth, the best temperature is lower than that for the growth of the shoot. Keep newly potted bulbs in a cool place (from 38 to 50 degrees) until the pot is literally full of roots. Roots will extend through the drainage holes when full growth has taken place. Do not be impatient. It will take two or three months to establish a well-developed root system. Add water as often as necessary to keep the soil moist.




A convenient method of shutting out the heat from a few bulbs — a large box with the open part shoved against the basement wall. A hinged top would be handy. The sand encourages root development, but bulbs can be grown successfully without it if it is not available.

After Care. — When you are sure that the roots have developed sufficiently, bring your bulbs to full light and

Paperwhite narcissi are easy to grow in water or in soil. They will add color and beauty to your classroom or home. (Roche photo)

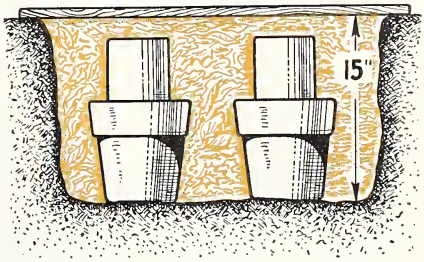
warmth gradually. The blooms will last longer if the bulbs are kept in a place that it not too warm. However, bulbs like plenty of light and water.

### Growing bulbs in water

Although Paperwhite narcissi can be grown in soil in the same way as tulips and hyacinths, it is interesting to grow a few of them in water, supported by stones. When buying, ask for bulbs that grow best in water.

#### SOMETHING TO DO

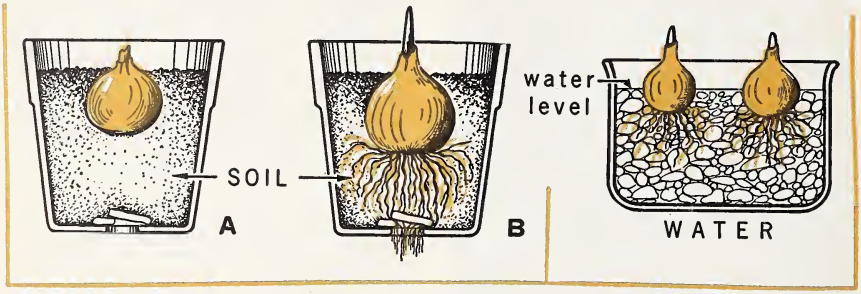
For a container, use a low bowl or a deep dish. Cover the bottom of the container with small stones or sand. Support the bulbs in an erect position by placing




A method of starting bulbs outdoors for *indoor* use. Prepare a pit as shown. Invert a tin can over each pot. Fill in around the pots with leaves. Place a board over the top of the pit. Move bulbs indoors on a mild winter day. In drier localities moisten the covering of leaves.

An attractive pot of tulips. (Photo by Kenneth McDonald & Sons, Ottawa)

stones around them. Then add water until nearly half the bulb is submerged. A few small pieces of charcoal among the stones, will keep the water from becoming foul. The container may then be placed in the light in a cool part of the room. If the temperature is much above 65 degrees Fahrenheit, the shoot will develop too quickly and the flowers will be inferior. Also, if the temperature is not too high, the blooms will last longer. When grown in water, Paperwhites should produce blooms in about six weeks. By starting a few bulbs every two weeks, you may have continuous bloom throughout the winter.




Left: A, A newly potted bulb. B, The same bulb, well rooted and ready to be moved gradually from its cool, dark location to warmth and light. Right: Paperwhite narcissi bulbs in water, supported by small stones.

### TEST YOUR KNOWLEDGE AND UNDERSTANDING

1. Describe a method of producing roots on a geranium slip, an African violet leaf, and an ivy slip.
2. What conditions are necessary for the healthy growth of house plants? How are these conditions provided in the average home or school?
3. Discuss the growing of winter flowering bulbs under the following headings: *kinds of bulbs, time of potting, containers, soil, planting, root development, care while blooming.*
4. How will you know when your bulb is ready to be brought out of the cool, dark conditions?
5. Describe the method of growing bulbs in water. What kinds of bulbs can be grown satisfactorily in this way? How can you provide for a succession of bloom?

### SOMETHING TO DO

Outline a good way of solving each of the following problems which are related to gardening and to the growing of indoor plants:

1. What fall preparation is necessary if you wish (1) to have three pots of tulips in full bloom in March, and (2) to grow radishes and lettuce in the spring before the outdoor growing season begins?

2. Suppose that, in the fall, you have a large healthy geranium plant. What method would you follow in order to produce from the large plant four plants that would be of proper size and in bloom for your window-box in the spring?

3. What conditions might cause a bin of potatoes to begin to spoil? How would you proceed to save the good potatoes in a bin in which you found a number of spoiled ones?

4. You have a house plant that is not thriving. Make a list of the probable reasons for its condition, and state how you would overcome each.

## BEYOND THE GARDEN IN FIELDS AND WOODS

In autumn, as well as in spring and summer, the prairies and woods are colored in many places by a wide variety of wild flowers. The flowers are there for us to enjoy — all we need to do is visit their growing places.

Two varieties of blazing stars are the meadow blazing star (left) and the dotted-leaved blazing star (right). The blazing star has purple flower heads. As the flowers open, vivid rose-purple parts appear and present a dull, smoldering glow. (W. C. McCalla photos)

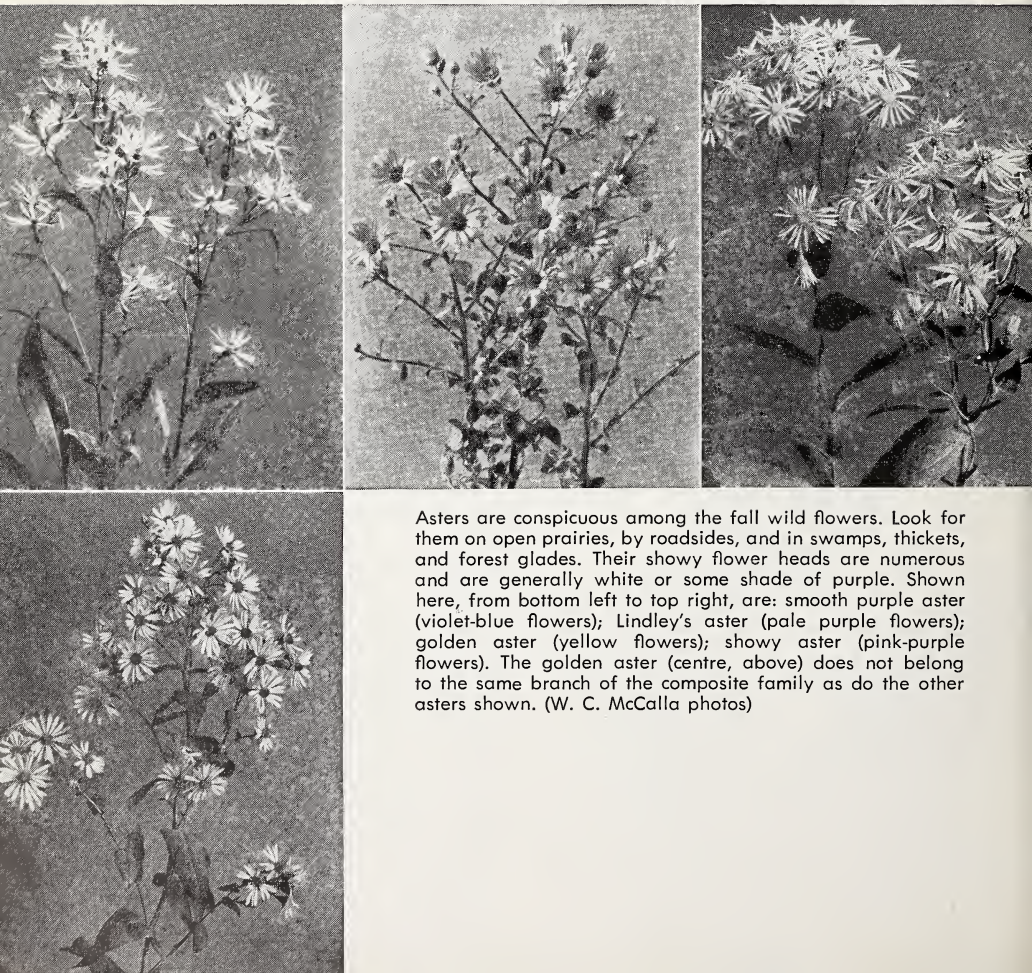
What are the names of some of the most common autumn wild flowers? What are their most common colors? How are seed pods adapted to scatter their seeds?

### How to look for wild flowers

Go for a walk across the fields or through the woods on a bright, warm fall day. Look for splashes of color that indicate patches of wild flowers. In some places, too, a single beautiful wild flower may be growing. Be sure to look sharply for such specimens.

Notice that some kinds of wild flowers are growing on the dry, open prairie. Others thrive in the shade, where moist, cool conditions exist.

Observe the many adaptations of wild flowers — color to attract insects, seed-scattering devices, large numbers of seeds produced by one plant.



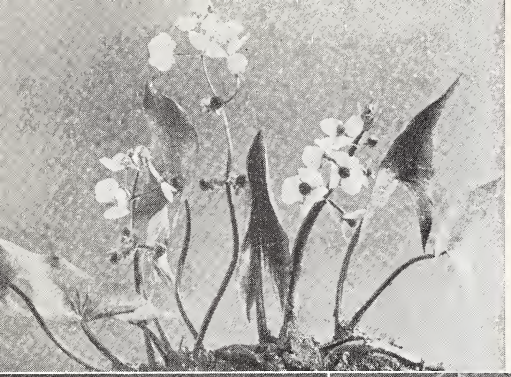
Asters are conspicuous among the fall wild flowers. Look for them on open prairies, by roadsides, and in swamps, thickets, and forest glades. Their showy flower heads are numerous and are generally white or some shade of purple. Shown here, from bottom left to top right, are: smooth purple aster (violet-blue flowers); Lindley's aster (pale purple flowers); golden aster (yellow flowers); showy aster (pink-purple flowers). The golden aster (centre, above) does not belong to the same branch of the composite family as do the other asters shown. (W. C. McCalla photos)

Be particularly careful not to pick wild flowers unless they are growing in abundance. Always be certain that plenty of flowers are left to produce seeds.

### Some ways in which seeds go travelling

As you will learn in Chapter 10, each seed is really a tiny plant with a supply of seed that is well sealed and

A great many fall wild flowers are members of the composite family of plants. Their flowers are small and are arranged in groups or heads. Members of this family shown below are (top left to right): pasture sage (low-growing, woody, covered with fine, silky-white hairs, yellowish flowers); everlasting (low-growing, whitish-woolly, heads numerous); wild sunflower (tall, leaves and stems rough, yellow flower heads 2½ inches across); (bottom left to right): fleabane (numerous flower heads, which are white, purplish, or pink); graceful goldenrod and stiff goldenrod (small, yellow flower heads arranged in clusters). (W. C. McCalla photos)



A group of interesting fall wild flowers are (top; bottom left to right): arrow-head (glistening white flowers, leaves mostly arrow-shaped); common evening primrose (flowers yellow, in leafy clusters, close in strong sunlight); willow-herb or fireweed (flowers showy, reddish-purple, common on newly burnt or cut-over ground); painted cup or Indian paint brush (greenish-yellow flowers surrounded by leaf-like parts which look as if they had been dipped in scarlet paint). (W. C. McCalla photos)

covered for protection. During the autumn, the seeds of many plants become scattered far and wide in numerous and interesting ways.

Some seed coverings are almost like coiled springs which are waiting for the exact moment when the seeds are ripe to "explode" and throw their seeds. If you look carefully, you will find seed casings of many shapes and with many kinds of openings, which may be at the top, side, or bottom. Some seed casings are very beautiful because of their striking colors and artistic markings.

As you learned in Chapter 2, seeds are contained in (1) *fleshy* fruits, such as apples, tomatoes, and raspberries, and in (2) *dry* fruits, such as *pods* (one compartment which splits open when seeds are ripe), *capsules* (several compartments, some of which open, others of which do not), and *nuts* (a single seed enclosed in a hard

covering). Many plants have *hooked* seeds.

#### SOMETHING TO DO

1. Go out into gardens, fields, and woods to look for caragana pods, winged maple seeds, poppy seed shakers, spikes of wheat, exploding violet capsules, seeds with parachutes, and other interesting forms of seed containers and distributors.

Look in both sunny and shady locations and examine all kinds of plants: trees, shrubs, wild flowers, weeds, and garden flowers and vegetables.

2. Make plans to collect and mount for an exhibit one good specimen of each type of seed covering that you find. (See page 18 for one suggestion.) Take pains to make your exhibit as accurate and attractive as possible.

3. Keep sufficiently detailed records of plants and their locations to enable you later to name the plants from which your specimens were taken.

4. Try to find and collect as many widely different types of seed pods and other coverings as you can, rather than too many of similar kinds.

5. Plan to make several trips — you can't do a job of this kind well in just one effort. Keep your eyes open on the way to and from school.

6. Your class might organize to make a co-operative study and collection. In a class collection a great many kinds of seeds and seed pods will be assembled.

7. If you are unable to identify your specimens by means of books and other aids at hand, enlist the assistance of someone in the community who could help you.

8. Give some attention to the great number of seeds produced by some plants. For example, one pigweed may have a million seeds.

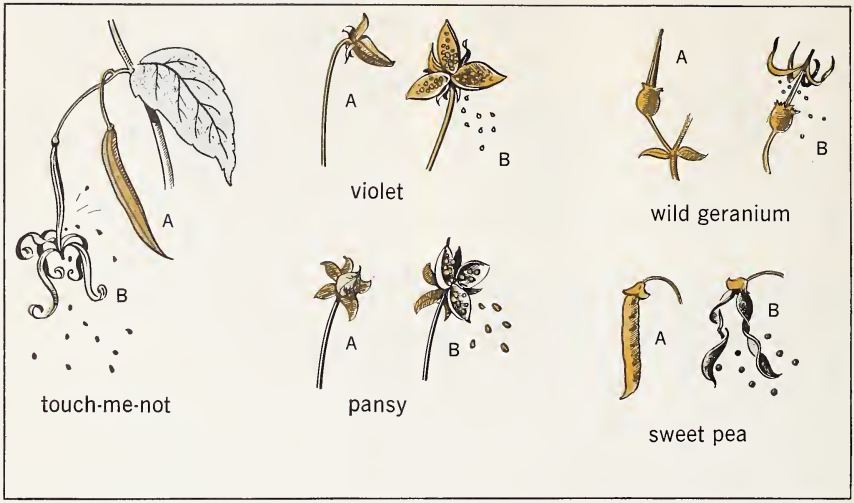
### Seed cases that explode

Seed containers which open with some force are marvellously equipped to open at exactly the right time. As pods develop, certain parts are put under tension or strain. Then some factor, such as wind, temperature, or moisture condition, causes the parts to spring open, often with sufficient force to throw the seeds several feet.

The *touch-me-not* or *jewel weed* grows in moist, shady locations. Its seeds are formed in containers that look like small beans. When you touch one, it explodes, and you may have difficulty in finding any of it. Two things happen almost too quickly for you to see: (1) The whole pod is thrown into the air. (2) As the pod falls, it shoots out its seeds. The touch-me-not pod has five springs fitted tightly together and held in place under considerable tension. At the right moment they are released, and curl up with the effect just described.

The *wild geranium* or *cranesbill*, with its reddish-purple flowers and hairy stems, is well known to many people. The seeds develop in a case with five parts, each of which resembles a hand gripping a tiny baseball. At length the springs in the "hands" suddenly coil outward and throw the seeds from the container.

*Violets* have two kinds of flowers: (1) the showy, exposed flower, and (2) a flower hidden in the trash near the ground. During the summer, the




Exploding seed containers before exploding (A) and after exploding (B).

hidden flower produces seeds in a case that is beautifully tinged with purple. Later on, the seed pods are raised above the ground. The seed case or capsule spreads open in three parts, each of which is full of seeds. The sides of each part are turned in by an ever increasing pressure, and the seeds are squeezed out one at a time with enough force to throw them up to six feet or more from the parent plant.

*Pansy* capsules scatter their seeds in the same manner.

### Seeds with parachutes, wings, and tails

Many seeds are equipped to sail or fly considerable distances through the air.

Examine *milkweed* pods carefully. Try to watch one as it opens. The pod opens along a line down one side. Then each part gradually rolls back from top to bottom. The seeds are arranged inside so that one by one they become free. Each seed is provided with a feathery parachute. However, the tip of each parachute clings to the pod until sufficient breeze springs up to carry the seed off to a new location. What would happen otherwise?

What other seeds provided with parachutes can you find? Examine *dandelions, goldenrod, thistles,* and others.

The *clematis,* a woody climbing vine, provides each seed with a curly tail that looks like a little feather. Pull a few seeds out of a *cattail.* What are their parachutes like?

The seeds of *maple, ash,* and *elm* trees are provided with different forms

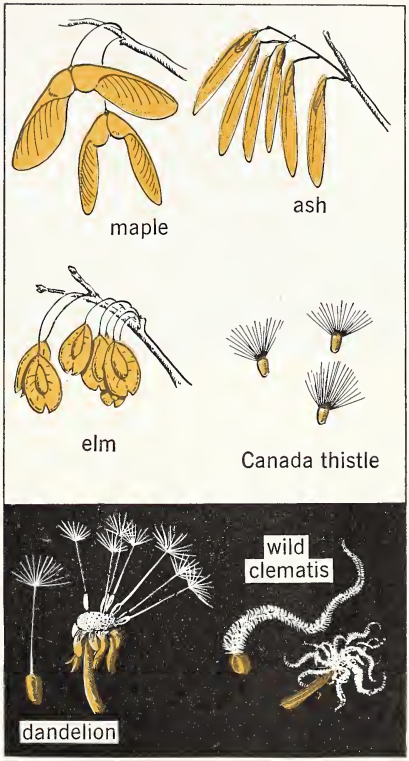
The opening seed-pod and parachute seeds of milkweed.

of wings which enable them to whirl through the air away from the parent tree. How does the fruit of the maple differ from that of the ash and the elm?

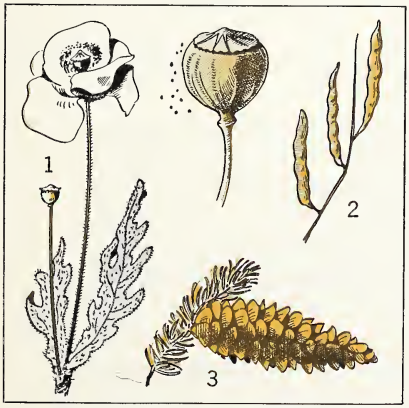
**Other seed containers**

By this time, you will have found numerous seed containers of a wide variety.

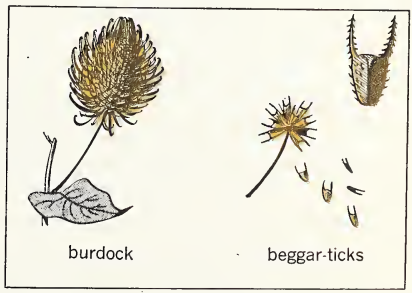
Have you examined *poppy* seed shakers? Poppy capsules do not split




Wind-spread seeds with wings or parachutes.




Some interesting seed containers: 1. poppy seed shaker; 2. mustard pods; 3. spruce cone.




Hooked seeds, such as burdock and beggar-ticks, steal rides.

The seed covering of the beaked hazel is extended to form a long tube. When you open the covering to get the hazel nut inside, the sharp hairs on the covering penetrate your skin. (Hugh M. Halliday photo)

open but develop holes around their tops. As the capsules are shaken by the wind, the seeds pour out.

Examine the *heads of grains.* Each has interesting adaptations. Each wheat seed, for example, is wrapped in a paper covering surrounded by a harder casing.

Examine *burdock seeds, beggar-ticks, burrs,* etc., to find the different ways in which seeds are equipped with hooks to steal rides on animals.

## WHAT HAVE YOU LEARNED?

### IMPORTANT SCIENCE IDEAS AND UNDERSTANDINGS

A

1. In the vegetable storage room, a cool temperature and moderately moist air are necessary.
2. Many plants may be reproduced by making cuttings and placing them in moist sand or vermiculite to become rooted.
3. Newly potted bulbs should be kept in a cool, dark place until they have developed a strong root system.
4. There are many things that should be done in a garden in the fall to ensure good growing conditions the following year.
5. House plants require moderate warmth, humid air, the right amount of water and light, and protection from harmful insects.
6. Ripened seeds are contained in *fleshy* coverings, such as apples and tomatoes, and in *dry* coverings, such as pods and nuts.
7. Explosive seeds have springs under tension that are released by wind, moisture, or temperature.

(a) The foregoing sentences are all true statements of important science ideas and understandings. Read and discuss them carefully as a review of this chapter.

(b) The following sentences describe situations in which some of these ideas apply. To test your ability to apply ideas to actual situations, match the sentences in A with situations in B to which they apply.

B

1. Malcolm Todd was walking past a caragana hedge. A slight movement in the hedge caught his attention. He stopped to investigate. As he watched, another caragana pod snapped open.

2. Mr. Anderson built a well-planned vegetable storage room in the basement of his new house. He knew that his family would be healthier if he could supply them with fresh cabbage, tomatoes, and other vegetables as far into the winter as possible.

3. When Ralph and Harry Reid saw how plants improved the appearance of their classroom at school, they decided that they would like to have a few in the window of their playroom at home. They asked their mother for some slips from the plants that she was growing in other parts of the house.

4. In September, members of Miss Peterson's class visited Mr. Brown's garden on a number of occasions. Mr. Brown always made them welcome, and they usually found him busily engaged in some gardening activity, such as digging manure into the soil, piling tops of plants into his compost box, pruning trees and shrubs, transplanting perennials.

## IMPORTANT SCIENCE TERMS

A

| | | |
|---|---|---|
| fruit | perennials | humidity |
| pod | drainage | compost |
| capsule | southern exposure | flowering bulbs |
| root system | root development | slips or cuttings |

To show that you understand and can use the science terms listed in A, match with the situations in B those terms which apply.

B

1. The pupils in Miss Peterson's class were delighted with the Paperwhite narcissi they had planted and that were now in bloom in their classroom.

2. The pupils also planted tulips in pots of soil. When, after some months, they found roots growing out through the drainage holes in the pots, they knew that it was time to move their bulbs into the light and warmth.

3. Ed Johnston had collected a number of dry seed casings. He found that most of them contained many seeds. Some had one compartment only, while others were composed of many compartments.

4. Mr. Brown told the pupils who visited his garden that he always piled up waste pea and bean vines, potato tops, etc., and left them to decay. When this material was well rotted, he dug it into his soil.

### SCIENTIFIC ATTITUDE AND METHOD

1. Bob Graham was thirteen years of age. He had always thought that the word *fruit* referred only to apples, pears, strawberries, and so on. One day in school, Bob and his classmates read the statement that pods and nuts are also classed as fruits. This was a new idea to Bob. However, he carefully checked his facts by reading and by talking with his classmates and teacher. He then accepted the statement as truth.

Which one or more of the scientific attitudes listed below did Bob display?

(*a*) *He was open-minded* — willing to change his opinion when he discovered new facts.

(*b*) *He was not superstitious* — knew that superstitions are foolish.

(*c*) *He based his decision on facts* — did not jump to a conclusion.

2. Bill Sinclair was not sure of the accuracy of the statement that *flowering bulbs had to be started in a cool place to develop a strong root system.*

(*a*) How could Bill use the scientific method to find out whether the statement was right or wrong?

(*b*) Supposing that Bill decided to experiment by starting one bulb in a warm place and another in a cool place — why should it be important for him to make sure that all conditions, except temperature, were exactly the same for each bulb?

(*c*) Did Bill use a sufficiently large enough number of bulbs to make it possible for him to come to a final conclusion? Give a reason for your answer.

Du Pont Company of Canada Limited

*When scientists discovered methods of making cloth fibres to supplement the natural fibres produced by plants, mammals, and insects, they opened the door to a showroom of textiles unmatched by the silks of the Orient and the fine fabrics of fiction.*

*—Selected*

CHAPTER 4

CHAPTER 4

# HOW SCIENCE IMPROVES OUR CLOTHING

**For thousands of years man depended on fibres obtained from plants and animals for most of his clothing. Within the past century, many new fibres have come out of the scientist's test tube. What are the common natural and synthetic fibres? How does clothing help us to keep warm in winter and cool in summer? Why do we wear light-colored clothes in summer? How have scientists helped us take care of our clothes?**

ONE SATURDAY AFTERNOON, several pupils met in Jackson's clothing store. As they talked with one another, they learned that each of them wanted to buy a different article of clothing.

Malcolm Gray was using some of the savings from his paper route to buy a new hockey sweater. He found a sweater bearing the crest of his favorite team, and asked Mr. Jackson if it were the most suitable one for him.

"You play hockey outdoors a great deal, Malcolm. I think you should buy a warmer sweater than this *cotton* one," advised Mr. Jackson. "The cotton sweater would be good if you were playing on an indoor rink, and would also be handy next spring, but for playing outdoors in this cold weather you should wear a sweater made of wool." Malcolm followed Mr. Jackson's advice and selected a green-and-white woollen sweater.

Charlie Hunt needed a basketball jersey. He wanted one that his mother could wash easily and frequently. He found a white cotton one which Mr. Jackson said was the best kind to wear when playing active indoor games such as basketball.

Anne Brooks was looking for a skirt to wear to her cousin's birthday party. She wanted one that would be both attractive and durable, and selected

a beautiful red one with a matching belt. Mr. Jackson assured her that she had chosen a skirt that was practical as well as attractive, and showed her the label which read *Made of Wool and Rayon.*

"The *rayon* fibres in this skirt will keep it looking attractive for a long time," he added as he handed Anne her parcel.

"Thank you," Anne replied. "Mother asked me to get two *linen* handkerchiefs for Dad. She said to be sure to get linen ones because linen dries quickly and is easy to keep white."

Meanwhile Edith Hopkins was examining girls' blouses.

"Which of these blouses do you like best?" she asked Anne. From the labels, the girls learned that blouses are made of various fibres. Edith found two that she liked very much. One was made of pale yellow *nylon,* the other of white *orlon.* Mr. Jackson advised her to choose the one she liked the better, because both kinds of cloth are strong and durable, will stay attractive, and are easy to wash. Edith finally chose the yellow nylon blouse.

## MANY FIBRES FOR MANY PURPOSES

When the pupils left Mr. Jackson's store and started to walk home, they continued to talk about kinds of cloth.

"I used to think that only girls should be interested in cloth," Charlie remarked. "But boys need to know

What qualities do you consider when you buy new clothing? (National Film Board photo)

about some kinds, too, so that they can buy clothing made of the best materials."

"That's right, Charlie," Malcolm admitted. "I always thought all sweaters were just about the same, but now I know that different kinds of fibres are made into sweaters for many different purposes. My woollen hockey sweater will be too warm next spring, but it will be just right when I'm outdoors on the rink."

"I'd like to learn something about fibres used in other ways besides those used in our clothes," interrupted Charlie. "Car upholstery, ropes, electric wires, and even fish lines and nets are made of cloth fibres."

"That's right," Malcolm added, "And Dad showed me the nylon cords in a tire."

"I learned something else about clothes today," said Edith. "Anne and I want our clothes to stay attractive and to be easy to wash. Malcolm wanted a sweater to keep him warm, and Charlie chose a jersey that would keep him cool. We buy clothes for different reasons."

"Boys want their clothes to have a good appearance, too," Malcolm asserted. "I suppose almost everyone wants to wear neat clothes. And everyone wants clothes that will wash well and last a long time. I think we choose clothes to suit the kind of work or play we are planning to do. If you were going on a hike or sleigh-ride you wouldn't choose the clothes you bought to go to a party."

The pupils agreed that we need a variety of cloth fibres for various purposes. "But I didn't know there were so many kinds," said Edith. "Today we saw wool, cotton, linen, rayon, nylon, and orlon cloth. On Monday, let's ask Miss Peterson where we get all these fibres, and why some of them keep you warm and others help you to stay cool."

### How winter clothing helps your body stay warm

When Miss Peterson heard of her pupils' experiences in the clothing store, she told them that in studying clothing they would learn more about heat.

"You remember," she said, "that we learned that warmth is one of our basic needs. To provide warmth, we use and control fire, and we build houses and wear clothing to keep heat from escaping."

From your study of foods, you remember that in the cells of your body, heat is produced when the food you digest combines with oxygen. You also know that your normal body temperature is 98.6°F. Your body works best at that temperature, and tries to stay there.

Outdoor temperatures in many parts of our country vary from far below zero on the coldest winter days to over one hundred degrees in the hottest summer weather. Your body needs some protection against such extremes and variations in temperature so that it can stay at its normal temperature.

In winter we wear clothing that keeps body heat from escaping. You will recall that dead air spaces are insulators. Why do we put storm windows on our houses in winter? For winter wear, we choose clothing containing millions of tiny air spaces, since these prevent loss of heat. Wool and fur are best for cold weather because they contain the greatest amount of insulating air. When we speak of warm clothing, we mean clothing that keeps heat from escaping; actually the cloth itself is not warm.

When we go outdoors in cold weather, we wear several layers of clothing. Between the layers are air spaces that prevent loss of heat. How would you find out whether two thin pairs of socks or gloves would keep your feet or hands warmer than one thicker pair made of the same material?

This mink coat, being inspected by its designer, was a Canadian gift to Queen Elizabeth. Why is fur a good material for winter clothing? (National Film Board photo)

### Cool summer clothing

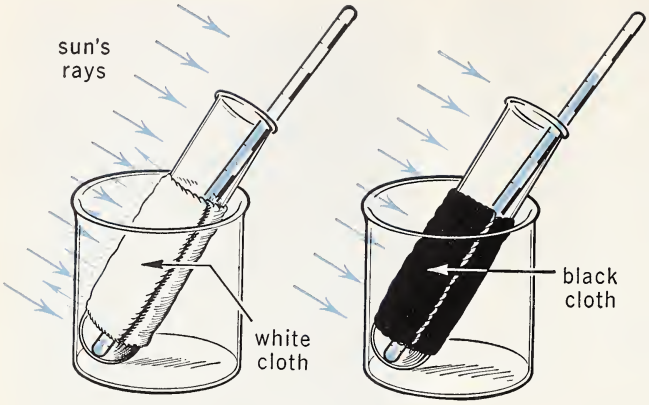
In hot weather your body may produce more heat than is needed to keep it at 98.6°F. Some of the excess heat radiates into the air. Your clothing should permit it to radiate quickly. For this reason, summer clothes are made of such fibres as cotton, linen, and rayon, which contain very few air spaces.

Your body has another method of losing excess heat in summer. You remember that you perspire on a hot day, or during a race or strenuous game. How does perspiring help you to keep cool?

#### SOMETHING TO DO

1. Let some water stand until it is the same temperature as the air in the room. Use a thermometer to check the temperature of both the air and the water. If necessary, add enough warm or cold water to change the temperature of the water to room temperature. Record this temperature. Tie a small piece of cotton cloth around the bulb of the thermometer, and dip it into the water. Remove the thermometer from the water, hold it for one minute, and read the temperature. What caused the difference?

You will remember that heat is required to change a liquid, such as




Which cloth is absorbing more heat from the sun's rays? From which one are some of the rays being reflected?

water, into a gas. When the water in the cloth evaporated, it took some heat from the liquid in the thermometer, causing a lower thermometer reading.

In hot weather, as perspiration evaporates from your skin, it requires heat which it takes from your body, thereby cooling it. The faster the moisture evaporates, the greater the cooling effect. For this reason we choose, for our summer clothes, fibres such as cotton, linen, and rayon, which absorb water readily and let it evaporate quickly.

2. Repeat the last experiment, but fan, with your hand, the wet cloth tied around the thermometer bulb. What happened to the thermometer reading? What effect did the breeze have on the amount of heat taken out of the thermometer bulb? Why does a breeze make us cooler on a hot day? Why should summer clothes be made of cloth which is woven loosely enough to let some air circulate through it?

**Light-colored clothes for summer wear**

One winter afternoon when Elaine Scott was helping her mother bring in the dry washing from the clothesline, she noticed that two handkerchiefs, one white and the other dark in color, had fallen on the snow. As she picked them up she was surprised to find that the dark-colored one stuck to the snow, as if the snow under it had melted slightly and then frozen again. The white handkerchief did not stick to the snow. What had happened to the dark cloth?

**SOMETHING TO DO**

Perform the experiment illustrated above. Check two thermometers to see if they both have the same room-temperature reading. Now stand them in two similar test tubes. Wrap a piece of white cloth around one test tube, and a piece of dark cloth of similar size and material around the other. Stand the tubes side by side in direct sunlight. After ten minutes read the temperature

in each tube. How would you explain the difference?

Repeat this experiment with light and dark pieces of several kinds of cloth. Why should you, as a young scientist, check your findings in this way?

The dark-colored cloth *absorbed* more of the sun's heat than the white one. Light-colored surfaces *reflect* or throw back more heat than dark ones. Can you now explain why Elaine's dark handkerchief stuck to the snow, while the white one did not? Why do you suppose that we prefer to wear light-colored clothes in summer?

**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

1. Different fibres are used to make clothes for various purposes. What should be the most important characteristics of the cloth used in making each of the following: a winter overcoat, a summer shirt, a party dress, a pair of overalls?
2. Explain how wool and fur help to keep us warm.
3. In what two ways does the body give off excess heat?
4. Describe an experiment that you have performed to find out if heat is used up when water evaporates.
5. (*a*) Why are light-colored clothes cooler in summer than dark clothes?

(*b*) Describe an experiment you would perform to find out if a white cotton shirt absorbs less heat than a dark blue shirt made of the same material.

## WHAT NATURAL FIBRES ARE USED IN MAKING CLOTH?

The skins of animals were probably the first clothing materials worn by man. Later, people learned to weave the hair of animals and the long fibres of plants into warm cloth. The four most common *natural fibres* used today in making cloth are *cotton, wool, linen,* and *silk.* Two of them, wool and silk, are produced by two members of the animal kingdom, the sheep and the silkworm. Cotton and linen are made of fibres which are obtained from two plants, cotton and flax.

### Wool for warmth

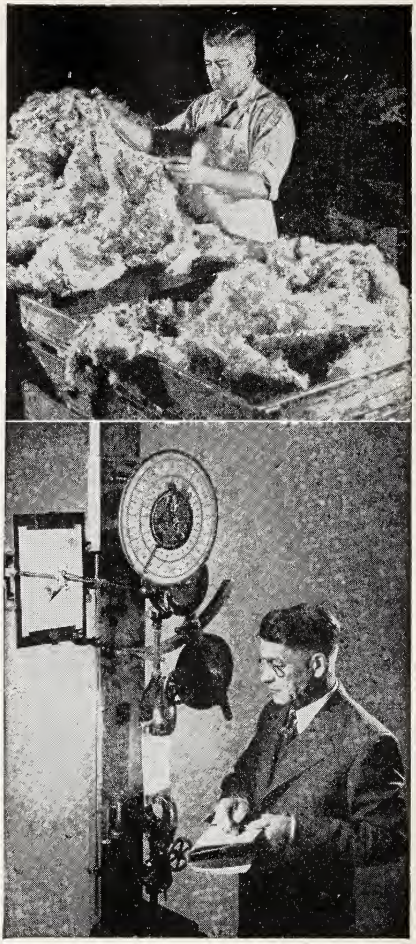
You have learned that woollen cloth is a good insulator. The many tiny air spaces enclosed in it prevent heat from escaping from your body. Why has woollen cloth more air spaces than other clothing materials?

Under a microscope, woollen fibres are seen to have layers of overlapping scales, somewhat like the scales of a fish. When these fibres are spun into yarn, the scales catch on each other, enclosing many small air pockets.

Why do the fibres in woollen yarn cling together?

**SOMETHING TO DO**

1. Pull a few fibres out of some woollen yarn. Do they slide out easily? What causes them to cling together? How does this make woollen yarn strong?
2. Burn some woollen yarn to test it for protein. Describe the odor. Compare it with that of burning lean meat, hair, or feathers, which have protein. Why should you expect wool to contain protein?
3. Test several pieces of cloth for wool content, using the protein odor test. Find out if any other fibres also have a protein odor when burned.
4. Prepare a report on the processing of wool from the time it is sheared until it is made into sweaters, woollen dresses, mittens, and socks.

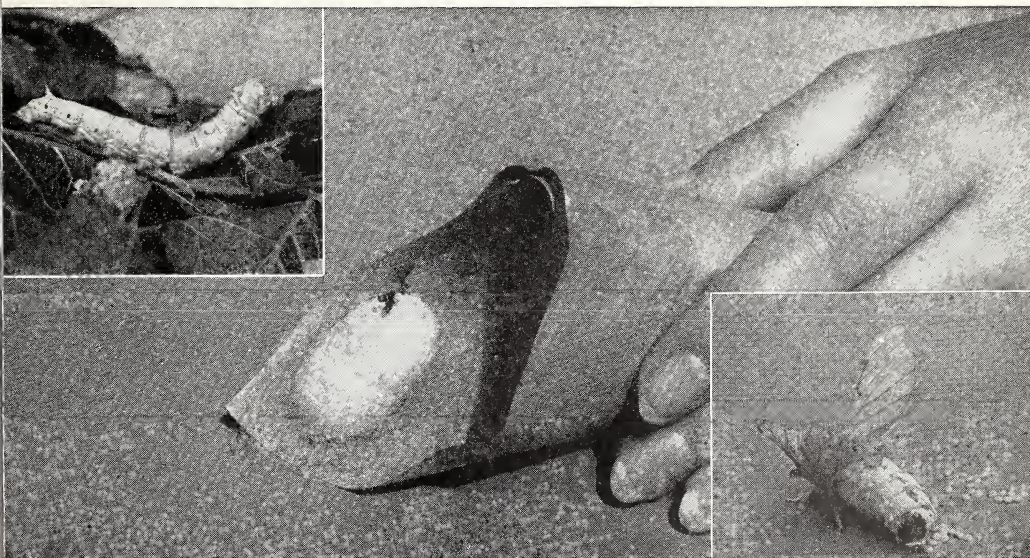


The quality of wool is checked several times before it is made into clothing. Top: Sorting wool into various grades. Bottom: Conducting a scientific test to check the strength of woollen cloth and to find out how much it stretches. (Wool Bureau photos)

The longer and finer the fibres of wool, the higher the quality of the yarn and cloth will be. Farmers and agricultural scientists work together to improve the quantity and the quality of the wool produced by selecting and cross-breeding sheep which produce large amounts of good wool.

Top: A flock of sheep grazing in rich pasture. Right: This Leicester ewe was judged the champion of her breed at the Royal Winter Fair. What good characteristics of her wool can you see? (Top, Ontario Agricultural College photo; right, Wool Bureau photo)

The life story of the silkworm moth. Left to right: A silkworm eating mulberry leaves; the cocoon with its covering of fine silk fibres; the female moth laying eggs. (Ward's Natural Science Establishment, Rochester, New York, photos)



### Cloth that comes from a cocoon

You have probably seen the fibrous outer covering of a cocoon. Perhaps you have watched a caterpillar spinning this covering, using the thin filaments produced by two glands in its head. You may be surprised to learn that *silk* cloth is made from similar fibres spun by another caterpillar, the silkworm, which spins fibres of silk about itself, forming a cocoon in which to become a moth.

The silk fibres are removed from silkworm cocoons after the cocoons have been soaked in hot water. Formerly, the fibres were removed by hand, but today modern machinery speeds up this work. From each cocoon is obtained an unbroken silk fibre over three-quarters of a mile long. The fibres are so thin that over a thousand cocoons are needed to obtain enough fibres to make one pound of silk cloth.

Silk is our most beautiful natural cloth fibre. However, the great amount of work required in producing it makes it expensive, and for many years people have sought an inexpensive substitute for it. This has been one of the most interesting and challenging problems faced by the scientists who experiment with cloth fibres. Later in this chapter you will find out whether scientists have been successful in their search for a substitute for silk.

### Cloth that comes from a seed pod

Many of your summer clothes are made of cotton. The fibres of cotton grow in the seed pod or *boll* of the cotton plant, a small shrub which thrives in warm climates. We obtain most of our cotton from the southern part of the United States.

Magnified cotton fibres. Why does cloth made from these fibres enclose fewer air spaces than woollen cloth?

#### SOMETHING TO DO

Examine some absorbent cotton, or cotton batting. Cotton batting is the mass of fibres which have been removed from the boll, separated from the seeds, and washed. Using a pin, separate one fibre. How long is it? Most cotton fibres are from one inch to two inches long. Under the microscope the fibres appear flat and twisted.

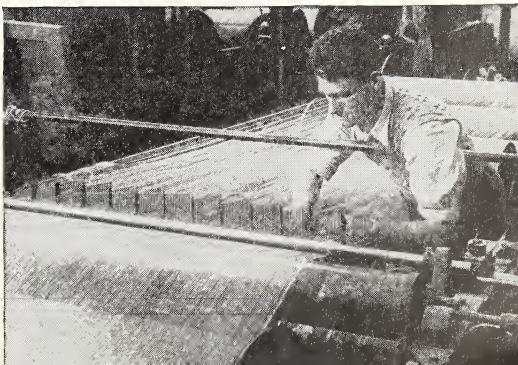
Burn a small amount of cotton. Is there an odor of burning protein? Describe the ash that remains. The fine grey ash and the absence of protein odor when burned, help us to identify cotton fibres.

Opened bolls of cotton, ready for picking. Do the fibres resemble cotton batting? In the picture above, a mechanical harvester picks the ripe bolls. (Top, National Cotton Council photo; right, Max Sauer photo)

**Cloth from flax plants**

The long, slim fibres in the stems of flax plants are used in making linen. Because the processing of these fibres requires a great deal of hand work, linen cloth is expensive. This cloth is seen most commonly in fine handkerchiefs, hand towels, and tablecloths. Some dresses are also made of it. Linen has several advantages as a clothing fibre. As it absorbs large amounts of moisture and dries quickly, it is therefore a good cloth for summer wear. Some kinds of cloth become yellow with age, but linen remains white. Fine linen dresses made several centuries ago, which you can see in an historical museum today, are proof of the durability of this fibre.

Left: Retting flax. The stalks are placed in water for about a week, until the covering has retted (rotted enough to loosen it from the linen fibres). Below: Arranging linen yarn on a loom which weaves it into cloth. (Irish Linen Guild photo)



Most of our linen comes from the British Isles, but in recent years scientists have developed improved strains of flax which are now being grown in Canada. Scientists who study cloth are trying to develop inexpensive fibres that have many of the same qualities as linen.

**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

1. (*a*) We use a number of natural fibres to make our clothing. What are the four natural fibres most commonly used?

(*b*) Which two fibres come from animals, and which ones come from plants?

2. (*a*) Describe the appearance of a wool fibre when it is seen through a microscope. How does it differ in appearance from a hair?

(*b*) How does the structure of wool fibres help to make wool yarn strong?

(*c*) How does the structure of wool fibres help to make woollen clothing warm?

3. Describe a test for wool.

4. (*a*) What is the natural source of the fibres that are used in making silk cloth?

(*b*) How are the fibres removed?

5. Describe and draw a cotton fibre as it appears under a microscope.

6. (*a*) Linen and silk are useful and beautiful kinds of cloth. Why do we not wear more linen and silk clothing?

(*b*) What problem has been assigned to the scientists who study cloth fibres?

## FIBRES FROM THE SCIENTIST'S TEST TUBE

For many centuries our clothing was made chiefly from the four fibres you have studied — wool, silk, cotton, and linen. The scarcity and high cost of silk and linen caused people to want a cheaper substitute for these two fibres. The first successful substitute was produced just before the beginning of the present century. Since that time, many other methods have been discovered for making and improving man-made fibres, until today much of the clothing we wear contains some of these *synthetic fibres*, used alone or combined with natural fibres. Synthetic fibres are ones made by man, rather than by nature, either by changing the form of a natural product, or by combining various chemicals to produce fibres.

### The discovery of rayon

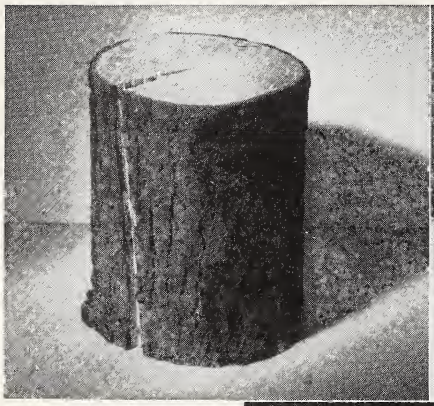
Most of us have been to an exhibition, fall fair, or trade fair. At these events we often see many of the most recent scientific and mechanical discoveries and inventions. If you could have attended the World's Fair held in Paris, France, in 1889, you would have seen the first successful substitute for silk. The display of "artificial silk," or rayon, was the result of years of study by a French scientist, Monsieur Chardonnet, who discovered the process by which this cloth is made. Chardonnet found that when he cooked certain kinds of *cellulose*, which is the solid part of the cell walls of plants, it could be dissolved in certain liquid chemicals. He then discovered that when thin streams of the liquid were dropped into an acid they hardened and formed long, thin, flexible fibres. When these fibres were spun into thread and then woven, they produced a soft, strong, durable cloth having the beauty of real silk. Chardonnet's discovery of the method of changing cellulose from plants into cloth fibres ranks high among science's contributions to the clothing industry. No longer did man have to rely solely on natural fibres. The new fibres could be made in various lengths and thicknesses to suit many new purposes. Later, scientists learned to make cloth fibres from other materials.

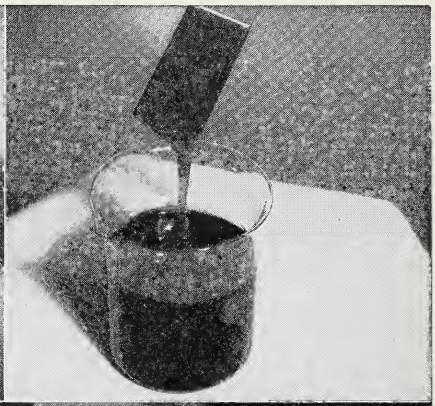
### Rayon—clothing from the spruce tree

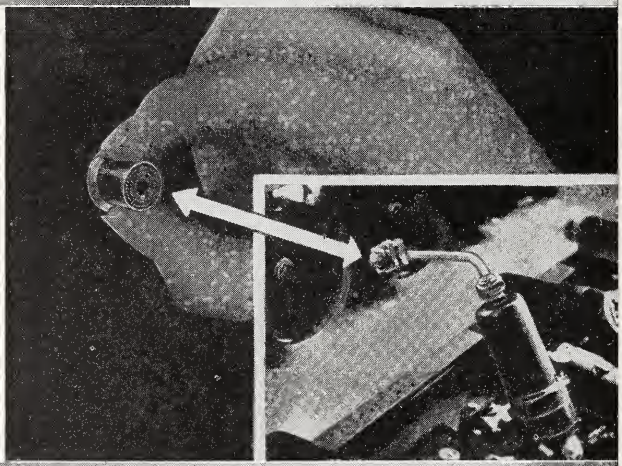
Rayon today ranks second only to cotton among all clothing fibres in the number of pounds used each year on our continent. It is used in more kinds of cloth than any other fibre. It can be woven into cloths which closely resemble silk, cotton, wool, and linen, and it can be combined with these natural fibres to improve them for certain kinds of clothing. Rayon cloth is less expensive than the materials it resembles.

Because rayon is produced scientifically, many of its qualities can be scientifically controlled. The scientists who help to make rayon fibres can control the length, thickness, strength, color, and lustre of every fibre. Is it any wonder that rayon is useful for so many purposes, from tire cords, lamp shades, blankets, and raincoats, to fine ties, shirts, and dress fabrics?

Most of the cellulose used in making rayon comes from spruce trees and cotton linters, the short fibres that cling to the cotton seeds. To make rayon from spruce trees, the logs are cut into wood chips, which are cooked until they become a soft mass of cellulose. The cellulose is broken up again into small, fluffy particles. This fine cellulose is now mixed with chemicals which change it into a liquid known as *viscose*, a sticky substance resembling golden liquid honey. The viscose is forced through a *spinneret*, or nozzle with tiny holes in it. After the fine streams of viscose are pumped through these holes, they pass through tanks of acid, where they harden into thin rayon fibres. When a number of fibres







The cellulose in the wood of the spruce tree is treated chemically, changing it to viscose, a liquid (above). The viscose is forced through the tiny holes of a spinneret (right). Then an acid bath solidifies it into long rayon fibres (below). (American Viscose Corporation photos)

Large booms of spruce logs float down the Ottawa River on their way to be made into rayon and paper. In the background are the Parliament Buildings. The round building is the Parliamentary Library. Beyond it is the Peace Tower. (Malak photo)

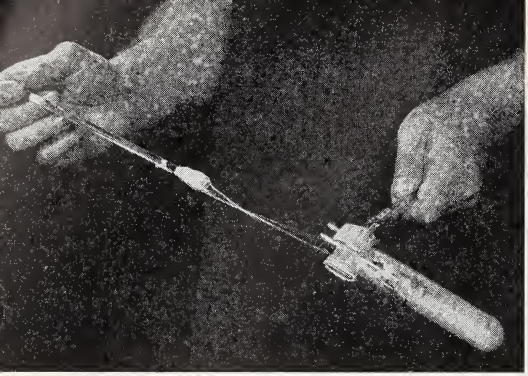
are twisted together, they become a rayon thread which can then be woven into cloth. Thus the manufacture of rayon involves changing a solid (cellulose) to a liquid (viscose) and back to a solid (rayon). One of the advantages of rayon is that the fibres can be of any desired length. Why is this possible? How does the making of rayon from viscose resemble the way in which the silkworm forms its filaments of silk?

### Cloth from coal

You have seen or heard of *nylon*, another substitute for silk, which is commonly used in making ladies' stockings and blouses, and men's shirts. Does it surprise you to learn that the method of producing this useful fibre was not discovered until 1934? Nylon was developed in the United States by Wallace Carrothers, a scientist who was making a very careful study of cloth fibres.

The chemicals used in making nylon come from *coal*, *air*, and *water*. The manufacture of nylon fibres is similar to the process by which rayon is made.

Nylon is popular because it has many advantages over most other



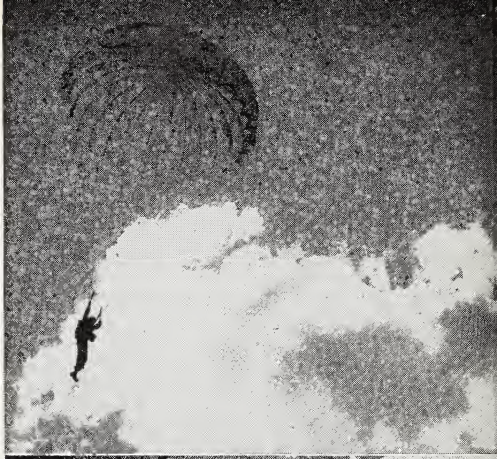
An experiment such as this one first showed the possibility of making nylon fibres. (Du Pont Company of Canada Limited photo)

fibres. These fibres can be made into cool summer materials, or they can be manufactured with enough air spaces enclosed in them to make winter clothes which insulate as well as wool. Nylon will stretch slightly and then return to its former shape. It washes easily and dries quickly. It is very light and yet very strong, and is not attacked by clothes moths. Besides its many uses in clothing, nylon is used to make fish nets, ropes, tire cords, car upholstery, parachutes, and hundreds of other useful articles.

### More and more new fibres

The search for new man-made fibres has not ceased. Rayon and nylon are constantly being improved, and new uses are found for them.

In 1951, another fibre, *orlon,* was developed from chemicals in coal, air, water, petroleum, and limestone.



Three uses of nylon. What properties of nylon make it useful for making parachutes, tents, and rope? Name two types of clothing made from nylon. For other uses of nylon see page 117. (Top photo, National Film Board; centre and bottom, Du Pont Company of Canada Limited photos) →

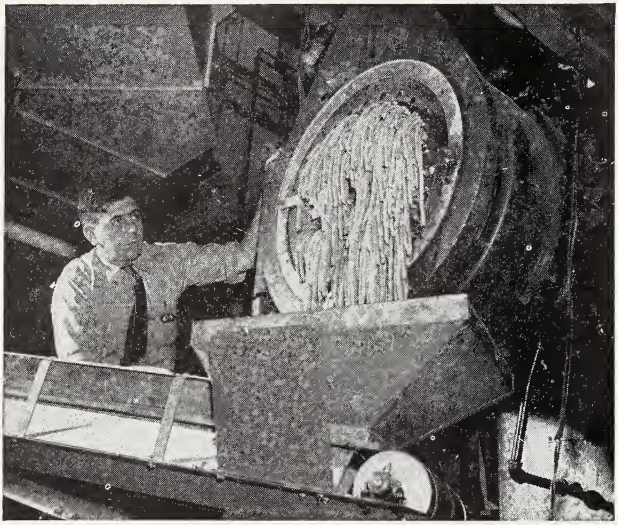
These curtains are made of orlon. What properties of orlon also make it useful for clothing? (Du Pont Company of Canada Limited photo)

Orlon has some advantages over other fibres. It weighs less than other fibres. Because it encloses many air spaces, it can be made into very warm clothing. It can also be made into light and cool fabrics. Orlon cloth will not stretch out of shape. Although it holds a crease longer than other materials, orlon does not wrinkle. Strong sunshine and rain cannot harm it.

In recent years, scientists have found methods of making cloth from *glass.* Fine glass fibres are spun together and woven into a very strong kind of cloth. As yet, cloth made from glass fibres is not used as clothing because it wears out quickly. However, glass fibres are made into fireproof draperies.

Another new man-made fibre, *lanital,* is made from the *casein* or

The fabric in these drapes is made of glass fibres. (Fiberglas Canada Limited photo)



Synthetic rubber going through a machine similar to a meat-grinder, which breaks up the large pieces and squeezes some of the moisture out of the rubber. The material is dried later and pressed into sheets. (United States Rubber Company photo)

curds of sour milk. Lanital is a warm material used chiefly for making sweaters.

In 1952, another new fibre, *dacron,* was developed. Like orlon, dacron is made of chemicals from coal, air, water, and petroleum. Suits made of dacron resist wrinkles and hold their press and shape. Dacron shirts and blouses do not have to be ironed; as soon as they are dry they are ready to wear again. (Some of the dacron manufactured in Canada and Great Britain is also called *terylene.*)

More and more new fibres will appear as scientists experiment with different materials. The search for better clothing materials will continue, but new synthetic fibres will not replace our natural fibres. More wool and cotton are produced today than ever before. Most modern fabrics now combine natural fibres such as wool and cotton with such synthetic fibres as rayon, nylon, orlon, and dacron. We all benefit in warmth, comfort, and economy from the work of scientists who study cloth fibres.

### Rubber and plastics

Before 1940, most of the rubber used in making overshoes, raincoats, and tires was obtained from the *latex,* or sap, of the rubber tree. Since 1940, scientists have discovered ways of making rubber from petroleum. The new synthetic rubber is found to be better in many ways than natural rubber. It wears longer and is not damaged by grease and oil. Today our rubber raincoats and footwear are made chiefly of synthetic rubber.

A few articles of clothing, such as transparent raincoats and overshoes,

are made from some of those new and wonderful materials, the *plastics*. Developed by modern science, plastics are made from wood fibres, soft coal, and many other materials.

Although synthetic rubber and plastics are used in making a few types of clothing, we do not call them clothing *fibres* because they are produced in sheets rather than as fibres which can be spun into yarn for making cloth.

What property of plastics makes them useful for making raincoats, umbrellas, and shower curtains? (Bituminous Coal Institute photo)

**SOMETHING TO DO**

1. Make a classroom collection of many kinds of cloth. Display them in three groups: *Natural Fibres, Synthetic Fibres,* and *Mixed Fibres.* Under each cloth show what fibres it contains, and explain in pictures or words the special uses that distinguish this particular type of cloth.

2. Make a collection of pictures showing uses of each of the synthetic fibres. Include both clothing and other uses.

3. Using a pair of tongs or pliers to protect your hands, burn small pieces of cloth made of each of the natural and synthetic fibres. Which ones burn most readily? Why must a *hot* iron *not* be used in ironing nylon?

**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

1. Why was Monsieur Chardonnet's discovery of rayon an important event in the clothing fibre industry? How does it help us today?

2. Briefly describe how rayon is made today.

3. Why is it that more kinds of cloth can be made from rayon than from wool or cotton?

4. (*a*) What three very common materials supply the chemicals used in making nylon?

(*b*) State three advantages of nylon.

5. What characteristic not found in natural fibres is the outstanding feature of orlon? Of dacron?

6. Name three other clothing materials which have been contributed by modern science.

7. More sheep are raised, and more cotton is grown, than ever before. Why have modern synthetic fibres not eliminated a need for wool and cotton?

## HOW SCIENCE HELPS US TAKE CARE OF OUR CLOTHING

Most of us like to wear clothes that are clean and neat. Clothes which are properly cleaned also last longer.

Water is the best cleaning material, because it will dissolve more substances than any other liquid. However, water alone will not remove all the dirt from soiled clothing. Oil from your skin soaks into your clothes. Dirt then sticks to them more easily. Why do we need soap or other cleaning materials in washing clothes?

#### SOMETHING TO DO

Pour a few drops of any kind of oil into a bottle of water. Shake the bottle containing the two liquids, then let it stand for a few minutes. What happened to the oil?

Add a few soap flakes or drops of liquid soap to the water and oil in the bottle, and again shake the bottle vigorously. What happened to the oil?

Oil and water do not mix readily. However, soap breaks the oil into very small droplets which mix more easily with the water. In this way, soap helps water remove oil and dirt from clothing.

Soap is made by boiling together a strong chemical called *lye* and some kind of *fat* such as tallow (beef fat) or lard from meat-packing plants.

In the last few years, science has developed several new products, called *detergents,* which dissolve oil so that it can be carried away by water. Usually detergents are better than soap for washing light clothing and dishes, but soap may be better for badly-soiled clothing.

### Protecting clothing from moths

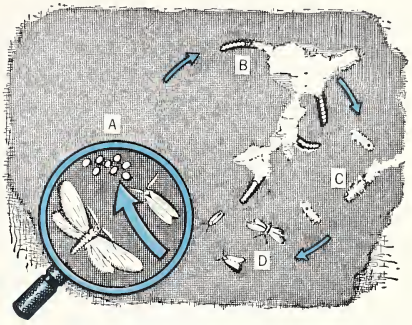
One cool autumn day Tom Blair removed his warm woollen sweater from the large trunk in which he kept it during the summer. He was both surprised and disappointed to find dozens of holes in the material. When he shook it, several small grey moths flew out of it.

Tom's sweater had been the home of a destructive household pest, the *clothes moth.* The adult moth does not eat clothes, but lays eggs in woollen clothing, furs, and rugs. The hungry larvae hatch in less than a week, and greedily eat the wool and fur. In three or four months the white larvae become half an inch long. They spin small cocoons of cloth fibres, and soon become adult clothes moths. In a day or two the moths begin to lay eggs from which the next generation will develop.

Tom was anxious to learn how to protect his other woollen clothes from this pest. He destroyed all the clothes moths he could find. At the library he found that clothes should be thoroughly cleaned before storing, and

should be packed in tightly closed boxes with a few moth balls or moth crystals. He also learned that clothes closets and other places where woollens are stored should be sprayed with a moth killer containing DDT, a recently developed insecticide.

Clothes moths feed on clothing of animal origin, such as wool and fur. One of the important advantages of rayon, nylon, orlon, dacron, and other synthetic fibres is that they are not attacked by moths. However, moths can damage any material made of synthetic fibre mixed with wool.




The life story of the clothes moth. A: Eggs (magnified). B: Larva eating holes in the woollen cloth. C: pupa rolled up in some of the cloth fibres. D: Adult moths. How can we destroy this pest?

## WHAT HAVE YOU LEARNED?

### IMPORTANT SCIENCE IDEAS AND UNDERSTANDINGS

A

1. Four natural fibres are used to manufacture clothing.
2. The tiny air spaces enclosed in certain kinds of cloth prevent heat from escaping from your body.
3. When a liquid such as water evaporates, it gains heat from its surroundings.
4. Light-colored objects absorb less heat than dark ones.
5. Chardonnet's discovery of the method of producing rayon from the cellulose in plant cells was an important achievement in the field of science.
6. Nylon fibres are very strong.
7. Dacron holds its shape and press, even after it has been washed.
8. Soap breaks oil into tiny droplets which can be mixed with water.
9. The larva of the clothes moth feeds on fur and wool.

**(a) The foregoing sentences are all true statements of important science ideas and understandings. Read and discuss them carefully as a review of this chapter.**

(b) The following sentences describe situations in which some of the ideas in A apply. To test your ability to apply ideas to actual situations, match the sentences in A with situations in B to which they apply.

B

1. Roger Forbes bought some new fishing line. Although it was very fine, he found it actually was stronger than the coarse line he had been using.
2. After finding some holes in her woollen scarf, Tom Blair's mother sprayed the clothes closet with a strong insecticide.
3. Malcolm Gray's woollen sweater kept him warm while he was skating on the pond.
4. The coach advised his baseball team to buy white or light grey uniforms.
5. Several of the boys went swimming one hot day during the summer holidays. The water felt pleasant, but when the boys came out of the water and began to dry off, they started to shiver.

## IMPORTANT SCIENCE TERMS

A

| | | |
|---|---|---|
| flax | absorb | detergent |
| orlon | natural fibres | cellulose |
| casein | synthetic fibres | spinneret |
| DDT | protein test | viscose |

To show that you understand and can use the science terms listed in A, match with the situations described in B those terms which apply.

B

1. It seemed strange to Sharon Kearns that nylon did not exist in nature, but was made of chemicals derived from coal, air, and water.
2. Tom Blair's mother found that her new insect spray destroyed all the moths in her clothes closets.
3. Lou Forbes examined some spruce fibres under the microscope. He noticed that each cell had a thick wall.
4. When Anne Brooks washes her mother's glass dishes, no soapy film is left on them.
5. When Roy Kendal was drying his woollen gloves, he hung one of them too near the hot stove. The pupils noticed a strong, unpleasant odor like that of meat or feathers burning.

**SCIENTIFIC METHOD AND ATTITUDE**

1. In a magazine, Ben Olson saw a startling headline that read: *Nylon Is As Strong As Steel!*

Ben wondered if this could be true, so he read the article. It said that scientists have found that a nylon thread or rope is as strong as a steel wire *of the same weight.* Ben decided to test their findings for himself.

(*a*) What wrong idea might Ben have gained if he had read only the headline?

(*b*) What attitude did he show when he read further?

(*c*) How should Ben perform his test? Why would he need a *coarse* nylon thread or rope? Why would the steel wire have to be finer? Why must the two be of the same length and weight?

2. Joan Wilson bought a cotton summer dress at a "bargain" sale. After she had worn it several times, she washed it in water with a new detergent that her mother was trying. After the dress dried, Joan could not get it on; it had shrunk. Joan blamed the detergent for shrinking her dress. Her mother explained, "The material in most good cotton dresses is pre-shrunk. Your dress has no pre-shrunk label. Yours is the only dress that has shrunk."

"I don't care," Joan replied, "this is the first time you've used this detergent, and this is the first time I've had a dress shrink, so it must have been the fault of the detergent."

(*a*) What scientific attitude did Joan fail to show?

(*b*) How could Joan have found out for herself whether the detergent was the cause of shrinkage?

(*c*) When is a "bargain" not really a bargain?

**TESTING YOURSELF**

To help you find out if you are developing the attitudes and skills of science, think about, and discuss the following questions:

1. (*a*) What new science problems occurred to you in the past month? How did you find answers to these problems?

(*b*) What new experiments or experiences did you arrange in solving these problems?

2. What science books have you read recently? Where are the science sections of your library?

3. What opinions did you change upon learning new facts? After studying clothing materials, are you a wiser shopper?

4. In science periods, do you know exactly what the problem is? Are your remarks in discussions confined to the problem?

5. Have you and a friend had any difference of opinion in science? If so, how have you worked out a correct answer to overcome the difference of opinion?

6. What information did you get from your parents or others to help you solve science problems? For example, did you ask your mother about her experiences with detergents, clothes moths, and various natural and synthetic fibres?

7. Have you based your conclusions on single experiments performed only once? Why is this not good scientific procedure?

8. Have you been performing the experiments so that you can really see the results and make your own conclusions, or have you been getting all your answers from books? It is important to do the experiments themselves. Have you repeated any at home?

9. Have you been accepting as fact, statements found in only *one* book or made by *one* person? Why is it important often to consult more than one book or one person to obtain reliable science information? Why are some books and some people more reliable than others as sources of science information?

## ARE YOU WORKING SCIENTIFICALLY?

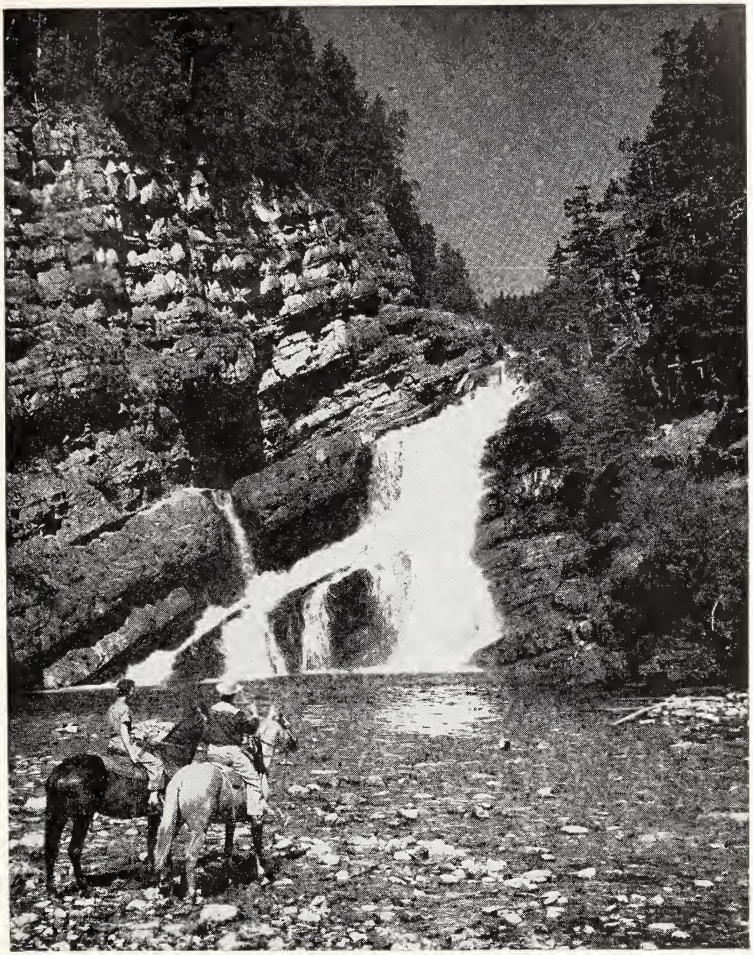
### SCIENTIFIC ATTITUDES AND SKILLS

A scientist has the following attitudes:

1. He is curious to know *how* and *why* things happen.
2. He bases his thinking on facts.
3. He is open-minded, or willing to change his opinion if the facts show him to be incorrect.
4. He knows that for everything that happens, there is a cause.

*Here are several other things that scientists do:*

1. They make very careful measurements in their experiments.
2. They repeat their experiments several times.
3. They read science books to gain new information.
4. They obtain information from experts in the field of science being studied. From whom could you get expert information about gardening? Building materials? Clothing materials?
5. They make careful first-hand observations.



Canadian Government Travel Bureau

*This earth, this beauteous land we call our own;*
*With rugged mountains, gently rolling plains,*
*Great rushing torrents, softly singing streams,*
*Whence came this strange and variable beauty?*
*What built the mountains, dug the canyons deep?*
*Grant us the thoughtful heart, the searching mind,*
*That we may understand and treasure all thy mysteries.*

*— Kathleen Bould*

# CHAPTER 5

CHAPTER 5

# THE EARTH'S CRUST

**The earth's crust is composed of many different kinds of rocks. By studying them, scientists are able to learn much about what happened on the earth millions of years ago. How do *you* think the mountains were formed? The Canadian Rockies are among our younger mountains. How old do you think they are? Sometimes the shells of sea animals are present in rocks high up on mountain ranges. What does this indicate? The surface of the earth has changed greatly through the centuries. What great changes have taken place and what has caused them? What do volcanoes and hot springs tell us about the interior of the earth?**

THE EARTH'S ANCIENT HISTORY is written in the rocks. Perhaps you have already read some of the pages from this history. Have you, for example, ever taken time to stand and stare at a towering rock-ribbed mountain and to wonder how and when it came into being? Or have you stood on the bank of a meandering river and let your imagination carry you back to a time, perhaps millions of years ago, when the stream had just begun to carve out a shallow, narrow gully? Since then the gully has been deepened and widened by the force of the running water, until it has finally become a deep, wide valley.

Perhaps you have been fortunate enough to motor along the Banff-Jasper highway to the Columbia Ice Fields. If you have, it is more than likely that you have marvelled at the great extent and depth of the glacier there, which is said to be all that remains on this continent of the Great Ice Age. Or again you may have been privileged to take a trip to Yellowstone National Park in the United States, where one may see large numbers of gushing geysers, steaming

colorful pools, petrified trees, and unusual rock formations.

Perhaps you have noticed in your travels through the Canadian Rockies that many of the mountains are composed of layers of rocks and that in many cases these layers are tilted upward while in others they are folded or bent in the form of an arch. How do you account for this?

Besides the mountains there are many other physical features in the Province of Alberta that should make the study of the earth's crust of particular interest to you. Some of these features are: glaciers, river valleys, canyons, waterfalls, hot springs, coal and oil deposits, prairie regions, and badlands.

The story of the earth is written in the rocks. It is a story of changes caused by many different forces. These changes are still going on. You will learn more about them as your study of the earth's crust proceeds.

The scenery on both the British Columbia and Alberta sides of the Rocky Mountains is among the finest in the world. In the illustration above Mirror Lake nestles at the foot of Beehive Mountain in Banff National Park, Alberta. How were mountains, glaciers, and lakes formed? Was the Beehive formed at the bottom of an ocean or inland sea? How do you know? (Canadian Government Travel Bureau photo)

## HOW OLD IS THE EARTH?

"As old as the hills" is an old saying that you likely have heard someone use. But exactly how old are the hills? How old are the rivers and the valleys? How old is our planet, the earth?

These are very difficult questions for you to answer. They are difficult even for scientists to answer. However, there are some scientists who have made a special study of the rocks and other physical features of the earth and who have ways of finding answers to these and other questions concerning the history of the earth. The branch of science that deals particularly with such matters is called *geology*, and a scientist who has spent many years studying geology is known as a *geologist*.

Geologists have supplied us with most of our information about when and how the earth was formed; what the earth's crust and the interior of the earth are like; and the nature and cause of the great changes in the

Geologists travel by helicopter to out-of-the-way places in order to study rocks. (Geological Survey of Canada photo)

earth's surface that have taken place through the centuries. Although geologists are not in complete agreement on some of these matters, they have provided us with a wealth of interesting scientific facts about the earth.

### How was the earth formed?

Many scientists think that probably the earth, in common with the other planets, originally consisted of a hot gaseous mass that had been torn away from the sun. This material gradually cooled and condensed into a molten, nearly spherical body surrounded by a dense atmosphere of water vapor and air. As further cooling took place, a solid crust of rock was formed at the surface, and the water vapor condensed to form oceans on the earth's surface. In the beginning the water that formed the oceans and seas contained little or no salt; it was fresh water.

#### SOMETHING TO DO

Watch the newspapers and magazines for new discoveries that scientists are making from time to time about the way the earth was formed. Report to your class any new information that you find.

### What is the earth's crust?

The crust of the earth is the outer solid area that forms the land masses, or continents, and which also underlies the oceans and the seas.

At one time the earth's crust was solid rock. Now, as you know, there is a covering of loose, broken-down rock material covering large areas of the earth's surface. This is called *mantle rock*. It lies on top of the *bed rock* from which it was formed.

The earth's crust extends downward below the surface to a depth of about 25 miles.

### What lies beneath the earth's crust?

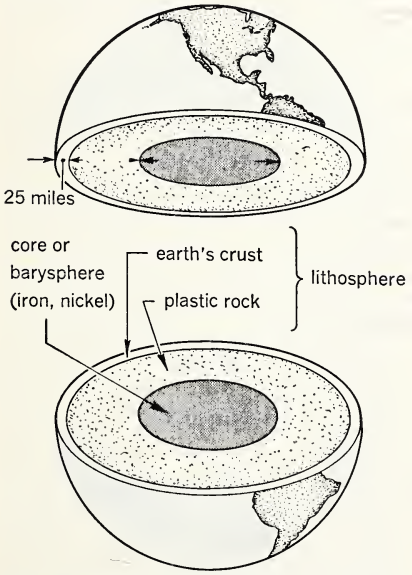
Temperature readings taken in oil-well borings show that the farther we probe below the earth's surface the higher the temperature becomes. The rise in temperature is about 1°F. for each additional 60-foot depth below the earth's surface. If the surface

temperature is 70°F., what would be the temperature at a depth of two miles? Assuming that the temperature increases at this same rate, at a depth of 25 miles it would be hot enough to melt rock. Geologists believe that immediately below the earth's crust is a layer of plastic, or semi-molten rock, extending to a depth of about 2000 miles.

This plastic rock area, together with the earth's crust, makes up the *lithosphere* (see diagram below).

### What is the centre of the earth like?

Formerly scientists believed that the centre of the earth consisted of a hot molten mass. They now advance another theory. Although it has not been proved beyond a doubt, most present-day scientists favor the theory that the central core of the earth consists of a solid ball of very hot metal. They say that this metal is composed chiefly of iron but that some nickel and other metals are also present. It is the heaviest part of the earth, being about ten times as heavy as water. The core of the earth is known as the *barysphere.*




A cross-section of the globe showing the lithosphere and barysphere.

### The four layers of the earth

As you have just learned, the earth is composed of four layers, or spheres. They are:

1. *Atmosphere* — The air mass that surrounds the earth and extends upwards from the earth's surface for about 200 miles or more.
2. *Hydrosphere*—The water sphere that consists of all the bodies of water on the earth's surface.
3. *Lithosphere* — The earth's crust, or thin outer solid layer, together with a thick plastic area.
4. *Barysphere*—A dense core which is made up of heavy metal, mostly iron.

It is the lithosphere that will be considered chiefly in this chapter.

### How do geologists estimate the age of the earth?

No one knows exactly how old the earth is; however, geologists and other scientists have tried to find the answer to this question. A number of ways of estimating the age of the earth have been used. Some of the methods are more accurate than others, but all of

them indicate that the earth is very old. Some of the observations upon which geologists have based their conclusions about the earth's age are considered briefly in this chapter.

1. Ocean water is salty. As you have learned, the water in the original oceans and seas at the time that the earth was formed contained little or no salt; that is, the water was "fresh." Today ocean water on the average contains 3.5 pounds of salt material in every 100 pounds of water. Geologists have calculated the total weight of salt present in all the oceans and salt-water seas. This salt, of course, has been carried into the oceans by rivers. They have estimated the amount of salt that has been carried by rivers into the oceans each year to be about 400,000,000 tons. By dividing the total weight of salt in the ocean by the weight of salt deposited in the ocean in one year, a rough estimate of the number of years required for the ocean water to reach its present degree of saltiness has been made. Although this is far from being an accurate method of determining the age of the earth, the results do indicate that the earth is very old.

A stream flows along the bottom of the deep, rocky, steep-walled Maligne Canyon, near Jasper, Alberta. How many years do you think it has taken the river to wear the rocks away to this great depth? (H. Rowed photo)

2. Erosion wears away mountains and valleys. Have you ever visited a canyon that has been cut out of solid rock by a rapidly flowing river? Such canyons as Maligne, near Jasper, and Johnson's and Marble canyons near Banff, are good examples. How many years do you think it took the rivers to erode these or similar canyons to their present depths? The erosion in any year is usually not great. Indeed, it may be unnoticeable. However, this process of wearing away rocks goes on, year after year, thereby changing the earth's surface. Over periods of thousands of years river valleys and canyons are gradually deepened. It has been estimated that it took the Colorado River more than a million

Seven Sisters Falls at Lake O'Hara, Yoho National Park, British Columbia. What evidence do you see here to indicate that the rocks that form these mountains are being broken up and carried away? (Canadian Government Travel Bureau photo)

years to carve out the Grand Canyon of Arizona, in its present form, from the plateau over which it once flowed.

By studying the structure and appearance of the rocks that make up the mountains, geologists can tell about how long it would take to wear the rocks down to their present form. They estimate that millions of years would be required.

3. Since the earth was first formed, mountain ranges here and there around the world have been built up by certain forces that you will learn more about later. At the same time other forces have been at work eroding or breaking down the mountains into more or less fine rock material. This material has been carried by streams and deposited as sediment in flat beds. Slowly but surely these sedimentary beds, which, as you will learn, finally become sedimentary rock, build up until, in some cases, they reach a depth of several thousand feet. Geologists know approximately the rate at which these deposits are built up. They are able therefore by measuring the thickness of the sediments to calculate roughly the number of years that the process has been taking place. They estimate that it has been millions of years.

4. If you have travelled through the Canadian Rockies by car or on one of the trans-continental railway lines, you will have seen many mountains which clearly show that they are composed of layer upon layer of rock material. The layers are not all alike as can be seen from their colors and textures. Usually a number of types of rock are represented. In some cases these layers are more or less horizontal; in others they are tilted or up-ended; and in still others they are folded in the shape of a hay-stack. Some of the layers are composed of sedimentary rock that was formed from sedimentary beds at the bottom of an ocean or of an inland sea, as was described in the preceding paragraph.

You will understand that enough time must have elapsed since the beginning of the earth for, in the first place, the beds of sedimentary rock to be formed; for, in the second place, certain forces to push these beds up to form mountains; and for, in the third place, the many centuries of erosion of the mountains themselves. It should be clear, therefore, that the earth is very, very old.

5. The best method that has been discovered by scientists for estimating the age of the earth makes use of our knowledge of radioactive elements, such as *uranium,* found in rocks. It is known that uranium breaks down or changes naturally, step by step, into other elements. One of the steps produces *radium;* another step, *thorium;* and the final step, *lead.* The form of lead produced is somewhat different from ordinary lead, and so it can be identified by scientists.

Uranium is found in rocks, and, as has already been stated, it changes without any outside help into a form of lead. The rate at which uranium changes into lead remains steady regardless of temperature or pressure. Scientists have measured this rate of change. Their measurements show that each year about $\frac{1}{7{,}600{,}000{,}000}$ of the mass of uranium in a rock changes to lead.

When scientists find certain weights of uranium and of the special kind of lead in a rock they can calculate the number of years that have passed since the uranium began to break up. This number gives us the age of the rocks. The age of the oldest rock measured in North America has been calculated by this method to be over 2,000,000,000 years.

On the basis of all the information available to them, geologists have been able to find answers to the problem stated at the beginning of this section. They have estimated that the earth has existed as a planet for about 5,000,000,000 years.

#### SOMETHING TO DO

Recently a method of using radioactive carbon (carbon – 14) for telling when certain things happened in the past, has been discovered by scientists. Watch for information about radioactive carbon as announced in newspapers and magazines. Two interesting and useful references on the subject are: "The Coming Ice Age," November 1958, *Reader's Digest,* and "How Old Is It?" August 1958, *National Geographic Magazine.* Report to your class any new information that you find about uses being made of carbon – 14.

#### TEST YOUR KNOWLEDGE AND UNDERSTANDING

1. On the basis of what you have learned in your study of the earth's crust, make a diagram to represent a cross-section of the earth. Label the spheres, or layers, that you show in your drawing. *After* completing your diagram, compare it with the one shown on page 145.

2. (*a*) What branch of science deals with the study of rocks, mineral deposits, and other features of the earth's crust?

(*b*) In what ways is the work of the geologist important to your province?

3. (*a*) Mention four methods that have been used to estimate the age of the earth.

(*b*) Which of these methods is considered to be the most accurate? Describe it.

4. On the basis of estimates by geologists, what is the approximate age of the earth expressed in billions of years?

5. Briefly outline evidence that you have found or seen in your locality which suggests that the earth is very old.

## HOW ARE ROCKS CLASSIFIED?

There are many different kinds of rocks present in the earth's crust. Scientists have studied these and have grouped or classified them according to how they were formed. This type of classification helps to make the study of rocks much easier.

#### SOMETHING TO DO

Make a collection of rocks. Gather as many different kinds of rocks as you can find in your locality. Select small rocks — the size of your fist, or smaller would be better. If possible, collect two samples of each kind. At school, or at home, classify your collection as best you can. One classification might be: hard rocks, soft rocks. Another classification might be: break in sheets, crumble, break like glass.

Keep your specimens for later study after which you should be able to classify them in other ways.

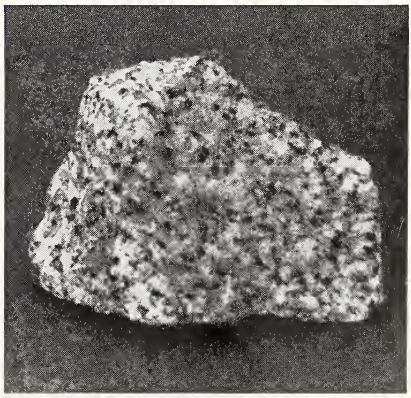
### What materials are present in rocks?

The outer part of the earth is composed of a variety of rocks and soil. The rocks differ in the ways they were formed and also in their appearance and structure.

#### SOMETHING TO DO

Are rocks composed of minerals? Examine a piece of coarse *granite*. Does it appear to be made up of different materials? Look for the following:

1. Large, white, pinkish, or grey crystals which are the mineral *feldspar*.



Granite is a common form of igneous rock. Be sure to include granite in your rock collection.

2. Small, thin, shiny flakes; these are the mineral *mica.*

3. Hard, glassy-looking material, which is the mineral *quartz.*

Feldspar, mica, and quartz are examples of minerals. *A mineral is an inorganic substance that occurs naturally and has a definite chemical composition.* To illustrate: *calcite* is a mineral. It is not formed from organisms such as plants and animals; therefore calcite is an *inorganic substance.* It is composed of three elements — calcium, carbon, and oxygen. These elements are always present in calcite in the same proportions; therefore calcite has a *definite chemical composition.*

Each kind of rock is composed of one or more *minerals;* and in turn each mineral is composed of one or more simple substances called *elements.* Seldom is a rock made up of only one mineral. Granite, as you have seen, contains three minerals, namely, mica, feldspar, and quartz. Actually two of these minerals, feldspar and quartz, comprise the greatest part of granite rocks.

Some minerals contain only one element, as for example, gold, silver, and carbon. More often a mineral is composed of two or more elements. For example, one common mineral, namely *quartz,* is composed of the two elements — silicon and oxygen. Other abundant minerals — *feldspar, hornblende,* and *mica,* each contain four or more of the following eight elements: oxygen, silicon, aluminum, iron, calcium, sodium, potassium, and magnesium. The first four of these elements — oxygen, silicon, aluminum, and iron — make up nearly 90 per cent of the earth's crust. These, together with calcium, sodium, potassium, and magnesium, comprise 98 per cent of the solid part of the earth.

There are many other elements present in rocks, some of which are of great importance to us. Among these would be: carbon, gold, silver, and copper. However, they make up a very small percentage of the earth's crust.

Explain how the rocks shown in this illustration were probably formed. What name is given to rocks of this type? (United States Geological Survey photo)

### The three main groups of rocks

Rocks are classified into three groups according to the way in which they were formed:

1. *Igneous,* or heat-formed rocks. They are formed by the cooling and hardening of hot molten rock from within the earth's crust. An example of igneous rock is granite.

2. *Sedimentary,* or water-formed rocks. They are formed, as you have

Marble is one of the common forms of "changed" or metamorphic rocks. How can it be distinguished from other rocks? (United States Geological Survey photo)

learned, by the hardening of sediments transported by water and deposited in beds. Sedimentary rocks usually occur in layers. *Shale* is an example.

3. *Metamorphic,* or changed rocks. These result when heat, pressure, or chemical action change the appearance and structure of rocks. *Marble,* for example, is a metamorphic rock that results from the transformation of *limestone.*

### Igneous rocks

The first main group into which rocks are classified is the *igneous* group.

#### Kinds of igneous rocks

There are many varieties of igneous rocks, all of which can be arranged in two groups according to where they are formed. (1) Some igneous rocks are formed from hot liquid rock material that reaches the earth's surface through volcanic action or through cracks in the earth's crust. (2) Others are formed below the earth's surface from liquid rock that is forced in among rock masses, where it slowly hardens.

Three kinds of igneous rocks: top, quartz basalt; centre, obsidian; bottom, pumice adhering to basalt cinder. (United States Geological Survey photos)

Igneous rocks formed from lava at the earth's surface include the following:

*Basalt* — dark grey to black in color; one of the commonest of the lava-type rocks.

*Obsidian* — dark brown to black; glossy; formed from lava that cools rapidly at the earth's surface.

*Pumice* — light grey; sponge-like; very light.

Igneous rocks that are formed by slow cooling far below the earth's surface include:

*Granite* — coarse-grained; composed of feldspar crystals, mica flakes, and glass-like quartz; typical colors — greys and pinks. Granite, the most widely distributed igneous rock, is abundant in the Canadian Rockies.

Igneous rocks are seldom in layers. They are usually crystalline or glassy in appearance and seldom contain fossils.

## Sedimentary rocks

The second main group into which rocks are classified is the *sedimentary* group.

### What materials are present in sedimentary rocks?

Most sedimentary rocks are formed from sediments that were produced by the erosion of rocks. There are, however, some sedimentary rocks which were formed from the remains of plants and animals and there are others that were formed from minerals, such as rock salt and gypsum, which, at one time, were dissolved in water.

### How are pulverized rock materials changed into sedimentary rocks?

There are a number of forces continually at work wearing away the rocks of the earth's crust. Some of these forces are wind, glacial action, and moving water in the form of rain, rivers, and ocean waves.

Other agents, such as sudden changes in temperature and the freezing of water in cracks in rocks, help to break up and wear away the rocks. As a result of these weathering and erosion processes, rock material is freed from solid rocks. This material consists of fragments of all sizes: large boulders; medium-sized pebbles;

A "flowerpot" rock formation on Georgian Bay, Ontario. How do you think the rock was eroded into this unusual shape? (Canadian Government Travel Bureau photo)

This huge boulder was transported to its present location by a glacier. How do glaciers change the earth's surface?

coarse gravel; sand; silt; and very fine clay particles.

These rock materials, and particularly the gravel, sand, silt, and clay, are carried by rivers into oceans and lakes. As a river enters an ocean, its speed slackens and the rock particles drop to the bottom. Gravel, being made up of larger, heavier fragments, drops first in the shallow water near shore. The sand drops later or farther from shore. The silt drops next, and finally the clay, being composed of the finest and lightest particles, is carried out farthest from the shore before settling to the bottom.

Sometimes there may be a little overlapping of these deposits; for example, there may be some clay in the sand area, or some sand mixed with the gravel; however, in general, the areas are quite distinct.

After these deposits of gravel, silt, and clay become hundreds of feet thick, they may be changed into rock in one of two ways. In the case of the clay and silt deposits, the great pressure of the top layers of rock material and water cause the fine particles at the bottom to be pressed together into a hard mass of rock. In the case of the coarser materials such as sand and gravel, the particles are cemented together by natural cements such as quartz and lime, which are present in solution in the water.

**SOMETHING TO DO**

*Problem.* — Why do sedimentary rocks form in layers?

To find the answer to this question perform the experiment that is outlined on page 218.

The rivers that bring down the sediments at flood periods carry the sediments farther out, so that a layer of sand may be deposited over a layer of clay. When the rivers are low, the flow of the water is slower and the clay settles to the bottom closer to the shore. This results in a layer of clay being deposited over a sand area. Also, rivers may be wearing away different kinds of rocks in different centuries; therefore a layer of yellow clay, for example, may be spread over

Scene near Willow Creek, Alberta. Notice the light-colored sandstone above and the brown shale below. These are sedimentary rocks. (Research Council of Alberta photo)

a dark grey clay deposit. In these and other ways layers are formed which differ in the color or in the size of the rock particles. Over millions of years these layers are changed into different kinds of sedimentary rocks.

### What are the chief kinds of sedimentary rocks?

The best way to study this topic would be to organize a field trip to find examples of different kinds of sedimentary rock somewhere in your locality. The rocks may be studied out-of-doors or samples may be brought back to school for later study. As you know, sedimentary rocks are *stratified;* therefore look for rocks in layers.

The following descriptions are provided to assist you in identifying sedimentary rocks:

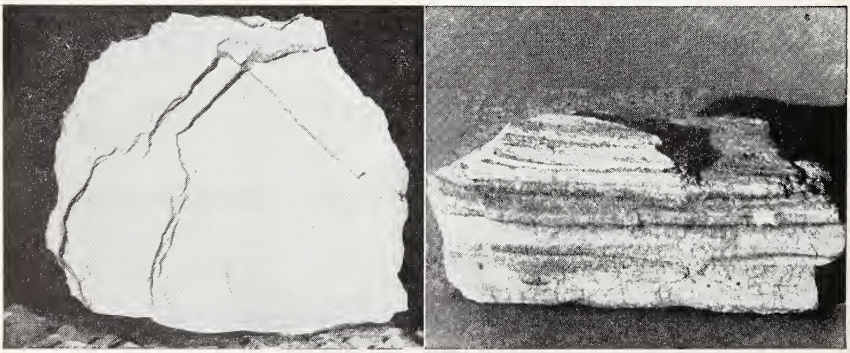
(1) *Shale* is formed from clay. (See types of soil, Chapter 7.) It is quite smooth and fine in texture, and occurs in a variety of colors such as white, yellow, grey, and black. It is rather soft and easily broken. Water cannot pass through this rock.

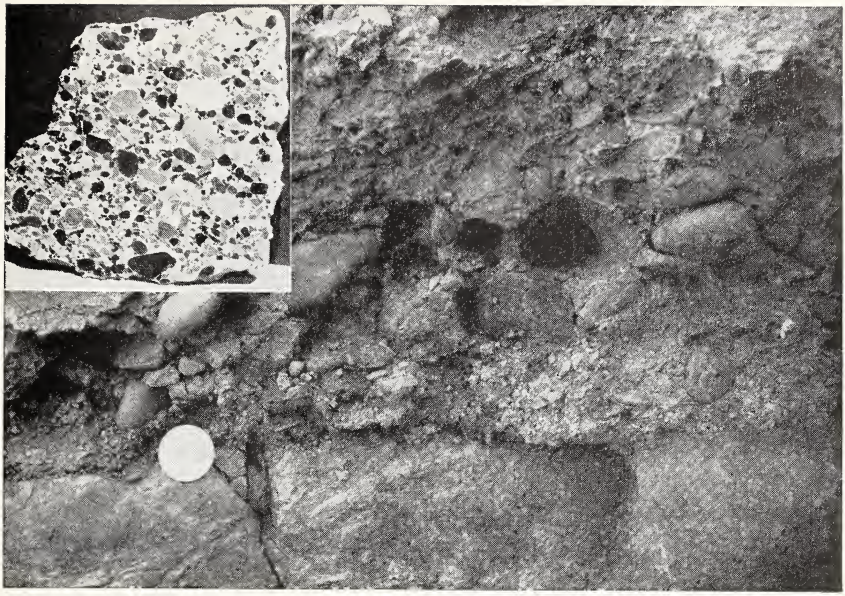
(2) *Sandstone* is formed from sand in which the mineral quartz is present in abundance. Common colors are white, grey, brown, and red. As sandstone is rather porous, water can pass through it. As a rule, sandstones are rough and hard. Sandstone has the appearance of fine sand that has been packed into a solid mass.

(3) *Conglomerate,* or pudding-stone, is formed from a mixture of gravel and sand. It resembles concrete in appearance. Some conglomerate rocks have their pebbles and small particles firmly cemented together; in others the fragments are held so loosely that they can easily be broken apart.

(4) *Limestone* is like the material present in the shells of animals. Indeed, much of our limestone was formed from the shells of animals that lived in the oceans and seas. Compact

Two examples of sedimentary rock: left, shale; right, sandstone. Note that both these rocks consist of many layers.





Conglomerate rock consisting of pebbles, sand, and clay cemented together. The white circle is a Canadian five-cent piece. Estimate the length in inches of the largest pebbles. To which of the three main classes of rock does this one belong? How has it been formed? Insert shows another conglomerate rock. (Geological Survey of Canada photo)

limestone is white, smooth, and fairly hard. *Chalk* is a form of limestone that is soft and very smooth.

**SOMETHING TO DO**

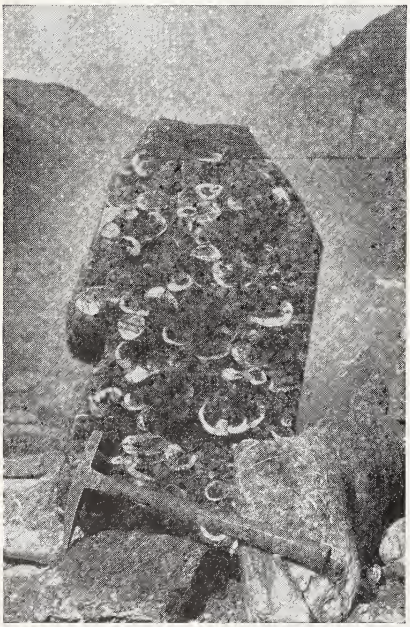
What is a test for limestone?

(*a*) Carefully pour a few drops of dilute (weak) hydrochloric acid onto a piece of limestone. Watch for the formation of bubbles of gas. Repeat the test using marble. (Marble is formed from limestone.) Do bubbles form as before? If hydrochloric acid is not available, use vinegar.

(*b*) Now drop dilute hydrochloric acid onto a number of other types of rocks such as granite, sandstone, shale,

A scene near Drumheller, Alberta. The flat-topped butte at the right is capped with a layer of hard sandstone. Notice the layers of rock. How would these rocks be classified? (Research Council of Alberta photo)

A strip mine near Blairmore, Alberta. The depth of the coal seam at the lower right is 90 feet. Notice how the rocks are folded and bent. Which one of the three main types of rock would they be? (Geological Survey of Canada photo)



Fossils embedded in limestone rock. How do fossils aid geologists in determining the age of rocks? (United States Geological Survey photo)

slate, gneiss (pronounced *nice*), and coal. Are bubbles produced as in part (*a*)?

What is a simple test for limestone?

(5) *Coal* is formed from plant life. It is usually found in layers in the earth's crust. *Lignite coal* is brown; *bituminous coal* is black.

Sometimes sedimentary rocks contain fossils. Indeed, the sedimentary rocks in certain areas of Alberta are rich in fossils. In Chapter 6 of this book you will find interesting information about these fossils — what they are, how they were formed, and the story they tell us.

### Metamorphic rocks

The third main group into which rocks are classified is the *metamorphic* group. These rocks were formerly other kinds which have gained a new appearance and structure because of the action of great forces within the earth's crust.

### How are metamorphic rocks formed?

You have already learned that metamorphic rocks are "changed" rocks. Bedrock within the earth may be changed by *intense heat* caused by the friction of shifting rock layers or by hot semi-molten rock moving in, through, and around it. This heat may be sufficient to melt the rock, and, when it hardens again, its structure has changed. *Increased pressure* developed through movements of the earth's crust may change old rocks into harder and more compact ones. A third way in which metamorphic rocks may be formed is by *chemical action.* Certain chemical processes may produce minerals that are different from those previously present, thereby changing the rock.

#### SOMETHING TO DO

Can clay be changed into hard rock by heat?

If there is a kiln in the art department of your school or elsewhere in your community, arrange to bake a handful of soft clay in it. Does the clay change to rock? If so, a metamorphic (changed) rock has been formed.

Porcelain vases, dishes, and the like are made by molding clay into the desired forms and then "firing" them in a kiln. Porcelain dishes, therefore, are metamorphic rocks.

### What are the common kinds of metamorphic rocks?

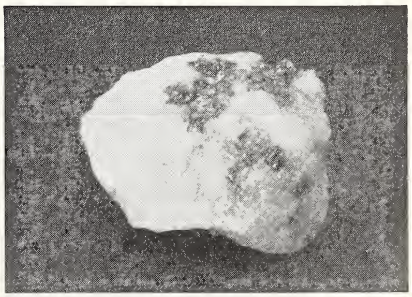
Metamorphic rocks, in common with the other two main types of rock, are identified by their general appearance, color, and composition. Several important kinds of metamorphic rocks are briefly described below:

*Marble* is one of the most common metamorphic rocks. It is formed from limestone. Pure marble is white, but impurities often give it a variety of attractive colors. Marble is hard and takes on a lovely polish. It makes a desirable building stone.

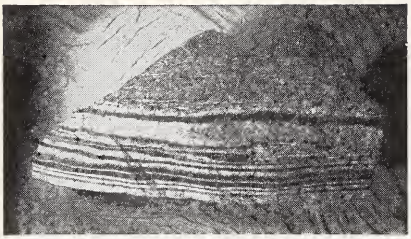
*Slate* is formed from shale. It is smooth, hard, and splits easily into layers. Formerly many school blackboards were made of slate. Examine the blackboards in your school to find whether they are slate.

*Quartzite* is formed from quartz and sandstone. It is a hard, durable rock, formed when quartz is deposited among the grains of sandstone.

*Gneiss* is usually derived from igneous rocks. Granite gneiss, for example, is formed from granite, which as you know, is a common igneous rock. One characteristic of gneiss is the alternating light and dark streaks or bands (see illustration, page 158). The colors are due to the



Quartzite is a metamorphic rock. This one was formed largely from quartz.



Banded gneiss — a metamorphic rock.

different minerals present. There are many varieties of gneiss.

*Schist* is similar to gneiss, but the bands are thinner.

*Anthracite* is formed from bituminous coal. It is hard and shiny black.

Metamorphic rocks usually contain large crystals. They very seldom contain fossils. Why?

#### SOMETHING TO DO

1. Visit buildings that are being erected in your community to find what kinds of stone, if any, are being used, and in what ways. Which are used for outside walls? Which for pillars? Which for stairways? Collect samples of all the different kinds of building stone that you can find. Label your samples as limestone, marble, granite, and so on. Keep your collection for reference.

2. If you have an opportunity to visit a museum, look for exhibits that will help you in your study of the earth's crust. Such exhibits would include: rock collections; fossils; charts showing how coal and oil were formed; charts illustrating the types of plants and animals developed through the ages; and others.

3. With the aid of the facts you have learned about the different kinds of rocks, you should now be able to classify your rock collection more accurately into the three main groups, namely: igneous, sedimentary, and metamorphic. Try to identify the different kinds of rocks in these three groups. How are the kinds of rocks in each group similar?

#### TEST YOUR KNOWLEDGE AND UNDERSTANDING

1. Rocks are composed of minerals. Mention three minerals that are common in rocks.

2. Name the four most abundant elements or simple substances present in the earth's crust. Name at least three other elements that are present.

3. (*a*) What are the three main groups into which rocks are classified on the basis of how they were formed?

(*b*) List at least three kinds of rocks that belong to each of the three classes referred to in (*a*).

4. Explain why sedimentary rocks are usually stratified, or in layers.

5. Suppose that you were given samples of the following rocks: limestone, granite, slate, conglomerate, shale, marble, and obsidian. How would you identify each of them?

6. Classify the rocks mentioned in question 5 as: heat formed; water formed; changed rocks.

Columbia Ice Fields on the Banff-Jasper Highway. By comparing the size of the chalet in the right foreground with the glacier on the left you can get an idea of the tremendous extent of the Ice Fields. Glaciers have changed the earth's surface by eroding valleys, by transporting rocks and soil great distances, and by forming rivers and lakes. (Alberta Government photo)

## HOW THE EARTH'S SURFACE CHANGES

You have already learned that the earth is very old, possibly 5,000,000,000 years old or more. When it was first formed, ages and ages ago, it was different in many respects from the earth as we know it today. Through the thousands of millions of years of its history, the earth has undergone great changes. Do you realize that the face of the earth is still undergoing changes? The processes that bring about the changes are going on all around you although you may have been unaware of them. Many of the changes take place so gradually over a period of so many years that it is unlikely that you would see any difference from one day to the next, or even from one year to the next. Some of the main forces that alter the earth's surface will be considered in this chapter. In order that you may learn, first-hand, about these forces, you should, if possible, carry out a number of the activities suggested below.

### SOMETHING TO DO

1. Organize, with the assistance of your science teacher, a field trip to find evidence of the weathering and erosion of rocks. Suggestions about what to look for are outlined in Chapter 7 in the section on "Planning a Field Trip."

2. Collect samples of different kinds of soil that are to be found in your locality. Which kinds were formed where they lie? Which were transported from some distance by rivers, winds, or glaciers?

3. Visit a nearby road cut, an excavation for a building, or a quarry, to study the rock and soil formations to be found there.

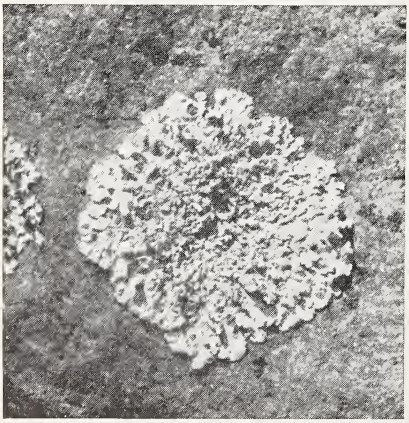
4. If possible, take a trip to the mountains to study rock formations, glaciers, moraines, hoodoos, hot springs,

Glaciers greatly changed the earth's crust by grinding rock into soil. A glacier has ground a trough across this rock surface. (Geological Survey of Canada photo)

waterfalls, and other interesting features of the earth's crust.

5. Visit a river valley. Observe it closely and think about what you see there. Try to visualize, and account for, all the changes that have taken place in the valley through the centuries since the river first flowed through this area.

At one time long ago, the surface of the earth was solid bed rock (see page 144). Now, large areas of the earth's surface are covered with pulverized rock material, or mantle. What agents have been responsible for changing bed rock into mantle rock?



Plants called lichens grow on rocks and help to wear them away. Explain.

### Weathering and erosion bring about changes

There are a number of natural forces continually at work breaking down rocks and carrying the rock fragments away to new locations. The part played by these various agents of soil formation is described in some detail in Chapter 7, pages 220 to 228. Here we shall refer to them quite briefly.

*Weathering*, or wearing away of rocks, is due to plants such as lichens that grow on rocks (see illustration) and to atmospheric agents such as frost action, sudden changes of temperature, and chemical effects of substances present in air. Weathering agents wear away rocks, but they do not carry the materials away.

*Erosion* includes not only the breaking down of rocks into smaller particles but also the transporting of these

rock materials, sometimes to far away places.

The most important forces of erosion are: winds, waves, rivers, and glaciers. What evidence have you seen of erosion caused by each of these natural forces?

**SOMETHING TO DO**

Make a list of changes in the earth's surface that have been brought about in the past by each of the forces of erosion (1) in your locality and (2) elsewhere in your province. Which of these forces are at work today, as in the past, changing the earth's surface?

## Rivers form valleys

Rivers are responsible for bringing about great changes in the earth's surface. They carve out valleys and canyons, transporting rock materials for great distances. Often a river valley is V-shaped due to the fact that the river bed and the banks are eroded at the same time.

Sometimes canyons and gorges have deep, nearly vertical sides. These are formed by swift-running rivers that cut down through the rock or the plateau. Maligne Canyon near Jasper and Marble Canyon near Banff are steep-walled canyons (see illustration

Rivers such as this one in Red Rock Canyon, Alberta, wear away rocks and transport the rock materials great distances. This action is called *erosion.* (Alberta Government photo)

Red Deer River Valley Badlands. Would these rocks be classified as igneous, sedimentary, or metamorphic? Give a reason for your answer. How do you account for the unusual rock formations shown here? What are they sometimes called? It is in these Badlands that many of the fossils shown in the next chapter were found.

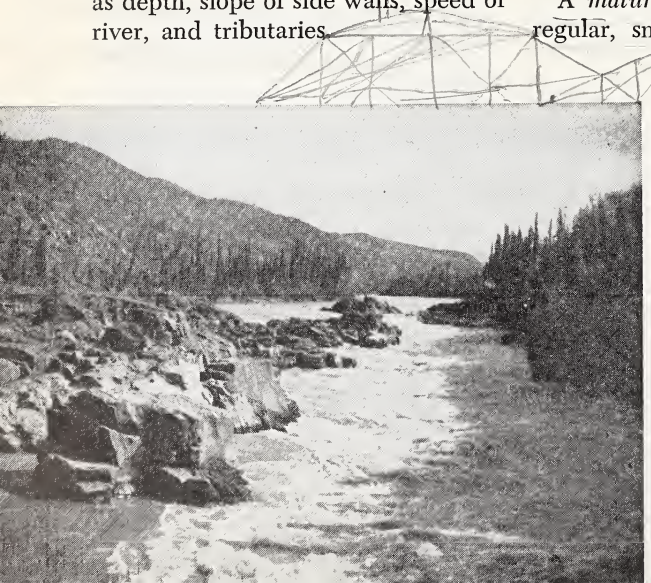
The Badlands on Red Deer River east of Steveville, Alberta. Erosion by wind and water is largely responsible for these formations. (Geological Survey of Canada photo)

on page 146). The Kicking Horse and Fraser Canyons in British Columbia, and the Grand Canyon of Arizona are other good examples of the result of erosion caused by the action of rivers. The Grand Canyon is an awe-inspiring sight. It is about 1 mile deep, 12 miles wide, and 200 miles in length — the largest canyon in the world.

River valleys are classified according to whether they are young, mature, or old. These terms do not refer to their actual age in years but rather to their general features such as depth, slope of side walls, speed of river, and tributaries.

A *young river valley* is one in which a swift river flows over a steep, irregular river bed. Usually there are rapids and waterfalls along its route. There are few branches emptying into it. The sides of the valley are rather steep. There is no wide level area at the bottom where the river runs. Study the illustration of a young river valley on this page. What valleys of this type have you seen? The Fraser and Skeena River Valleys in British Columbia and the Bow River Valley in Alberta are examples.

A *mature river valley* has a fairly regular, smoothly sloping river bed



A young river valley. Compare it with the mature river valley on page 163. In what ways do they differ? How long do you think it may take to change this young valley into a mature valley? (Geological Survey of Canada photo)

A mature river valley. How do the width of the valley, the steepness of its sides, and the speed of the river in this valley compare with these same features in the the young river valley on page 162? (Geological Survey of Canada photo)

Looking down the Bow River west of Ozada, Alberta. Study the illustration closely. Is the river valley young or mature? Give reasons for your answer. (Research Council of Alberta photo)

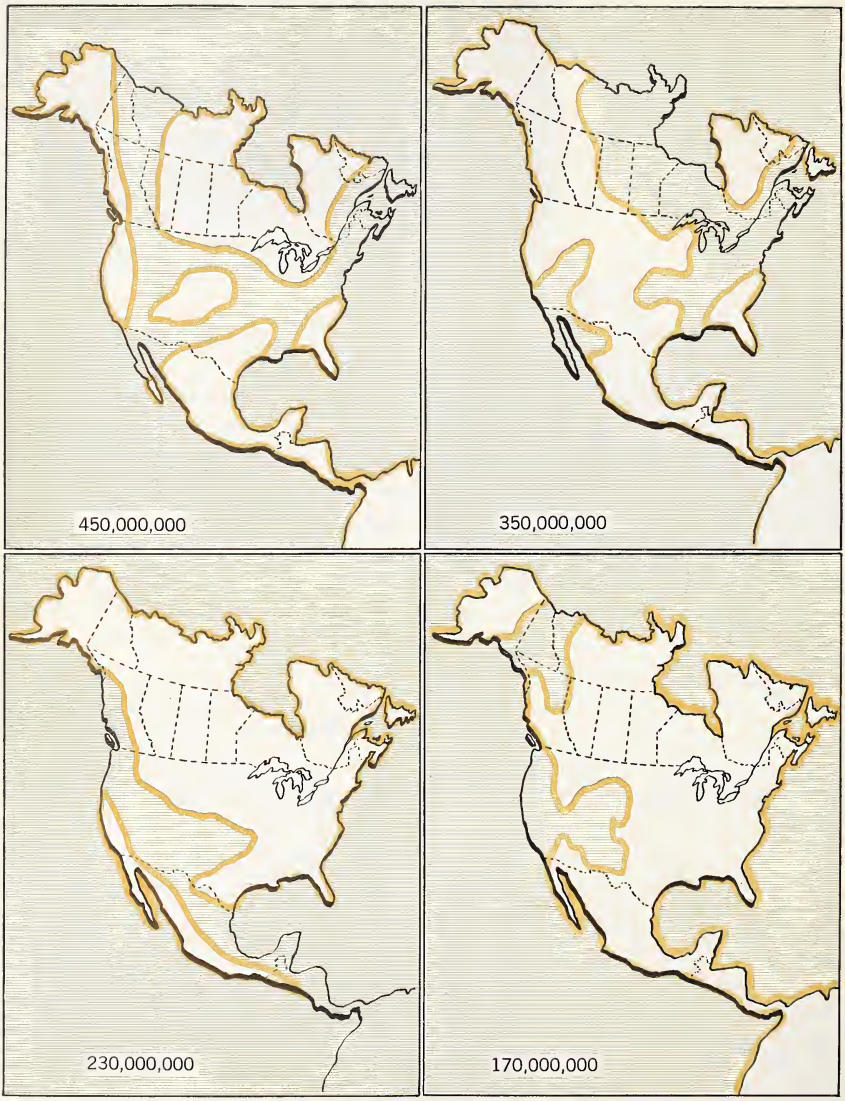
without rapids or waterfalls. (They have been worn away.) Since the grade is not steep, the speed of the river is much slower than that of a young river, and the erosion of the bed is thereby reduced. Erosion of the sides of the valley has resulted in a wider valley with more gentle slopes. A mature valley is wide, and the river meanders along its broad, flat flood plains with winding curves. There are usually many tributaries emptying into a mature river to increase its volume. Study the illustrations of a mature river valley at the right, above. What mature river valleys do you know? The Crow's Nest River Valley is one example.

An *old river valley* differs from a mature valley only in degree. It is broader and flatter, with less side erosion and fewer tributaries. The flow of the river is slower, and there is less erosion of the river bed.

A river valley may have the characteristics of a young valley near its source, of a mature valley farther along its route, and of an old valley at its mouth.

**The earth's crust is subject to great movements**

Although the earth's surface seems to us to be steady and firm, there is evidence to indicate that there has been, and that there still is, considerable shifting of the earth's crust. Actual measurements by scientists in recent years have shown that there has been a rise of certain coastal areas of Sweden of three feet in the last 100 years. The Dogger Banks, which now lie 60 feet below the surface in the North Sea, formed a heavily forested island not so very long ago. Then it sank beneath the surface of the sea. Similarly, stone huts that had been built on the southern shores of




The above map shows North America as it appeared at four different periods previous to our time. The numbers tell in years how long ago each of these conditions occurred. At each of these times, was your province under the sea or on dry land? Did the Rocky Mountains exist during each of these periods? How do you know?

Greenland have disappeared below the water's surface. These examples and other scientific evidence show that, in modern times, the land is rising in some parts of the world, while in other parts it is sinking.

There is plenty of evidence, also, to show that great movements of the earth's crust took place millions of years ago. Sedimentary rocks containing shells of sea animals and marine fossils are present near the tops of inland mountains. These sedimentary rocks must have been formed at the bottom of an inland sea or ocean. Then something happened within the earth to cause these layers of rocks to be raised up in the form of mountains that are now thousands of feet above sea level.

Geologists tell us that the rocks that make up the Canadian Rockies were formed many millions of years ago at the bottom of an inland sea that stretched from the Gulf of Mexico to the Arctic Ocean. The illustration on page 164 shows the location of the inland sea at that time. At a much later date in the earth's history, these rocks were heaved up into their present location.

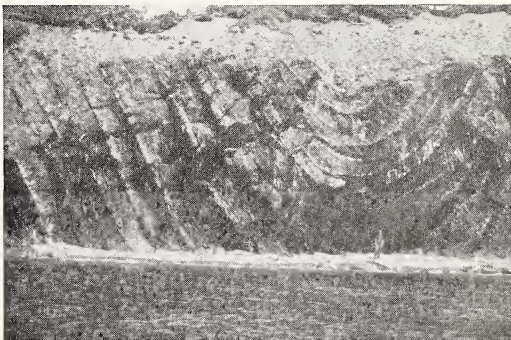
Just what causes these great movements of land masses has not yet been finally agreed upon by scientists; however, there is no doubt that these land movements result in great changes in the earth's surface.

### How are mountains formed?

While it is generally accepted that upward and downward movements of the earth's crust have been taking place continuously through the ages and are still going on, there have been periods in the history of the earth, millions of years ago, when tremendous upheavals resulted in the formation of mountains. Scientists do not agree on the nature of the forces that caused these upheavals. One theory is that the cooling of the hot semi-molten material deep inside the earth made it smaller and that this, in turn, caused shrinking and buckling of the earth's crust. The process is compared to the shrinking of the outer

This geologist has been making a study of an anticline. Observe how the rocks have been folded or bent. Are the layers composed of different kinds of rocks? (Geological Survey of Canada photo)

This is a syncline. Compare its structure with that of the anticline shown in the illustration at the left. How do you think these layers of slate were bent into this shape? (Geological Survey of Canada photo)



surface of a baked apple when it is allowed to cool. Another theory is that the weight of great depths of sediment or of ice, deposited in certain areas, exert a downward pressure and movement on the semi-molten materials within the earth, causing them to exert an upward force somewhere else. Whatever the cause or the causes, there is plenty of evidence that parts of the earth's crust have been forced to move upward or downward or sideways at some time in the earth's history.

### Folding of the earth's crust forms mountains

Many of our mountains were made by folding. The huge folds of rock that were pushed up were later eroded by wind, water, and ice.

#### SOMETHING TO DO

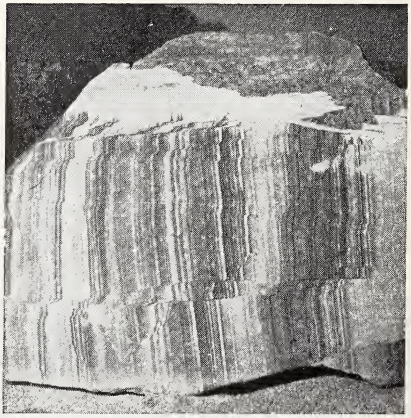
1. If possible, go on a field trip to a place where a highway has been cut through a rocky hill; or better still, go to the foothills or the mountains to look for evidence of the folding of the earth's crust. You may find sedimentary rocks that have been subjected to side pressure causing them to fold into a series of large, wave-like forms. Look also for layers of rocks that are sloping or inclined; some of them may be almost vertical. Report all your observations to your classmates.

2. You can easily illustrate, as described below, how great lateral (side) pressures might cause folding of layers of rock. Place two or three heavy towels, preferably of different colors, on top of one another on a table, desk, or floor. With a hand at each end, press gently toward the centre. Does the pressure result in wave-like folds? This illustrates how folds in the earth's crust may have been formed by lateral, or side pressure.

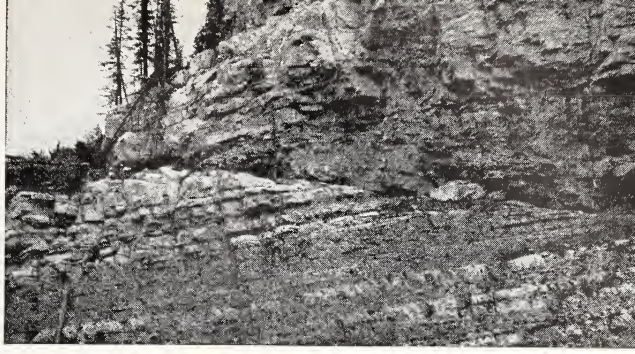
Folding of the earth's crust may be caused by pressure from inside the earth, as mentioned in the previous section, or by lateral, or sideways, pressure. It is likely that heat also plays a part.

An upward folding of the rock is called an *anticline*, and a downward folding is called a *syncline*. Comparing this folding with waves, an anticline would correspond with the crest of a wave, and a syncline with the trough. As a rule, anticlines and synclines are most commonly found in the softer rocks such as limestone and shale.

Observe the illustrations of folding on page 165. Folds may extend for only a few feet or they may extend for miles.



Small faults in a sedimentary rock. Notice that along the cracks, or faults, the layers have shifted out of line.



A large fault in sedimentary rocks in Moose Mountain, Alberta. Notice the fault line running across the centre of the picture. Before the fault occurred, the layers of rocks above and below the fault were in one continuous line. (Geological Survey of Canada photo)

### Faulting may result from extreme folding

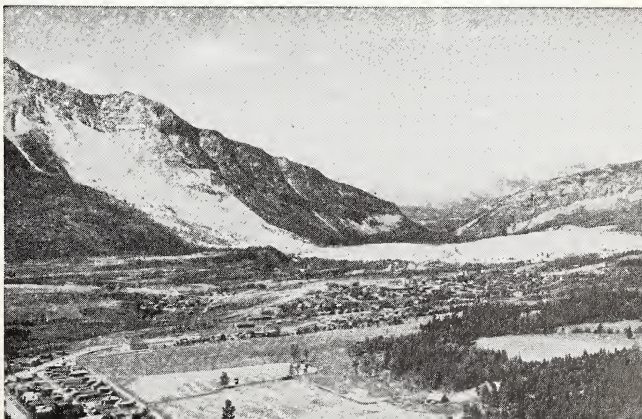
It sometimes happens that when lateral pressures on layers of rock are very great and continuous, one fold is forced up over the top of another lying next to it. This causes the rock to break, forming a *fault* or fracture (see illustration above). Faults sometimes extend for many miles.

Frequently faulting leads to *slipping* with the result that the layers of rock on each side of the fracture, or crack, no longer match. (See illustrations above and on page 166).

### Faulting causes many earthquakes

The faulting and the sudden slipping of the rocks may cause the bedrock to tremble and shake. These vibrations of the earth are known as *earthquake shocks.* If the faulting causes violent shaking, the earthquake produced is likely to destroy buildings with probable loss of life. On the other hand, if the faulting is on a very small scale, a sensitive instrument may be required to detect the tremors. The earthquake shocks are strongest along the line of the fault. Violent tremors may last for several minutes and faint tremors for only a few seconds.

Although faulting is the chief cause of earthquakes, there are other causes as well. Volcanoes sometimes erupt so violently that earthquake shocks are produced. Faint earth tremors are



On April 29, 1903, at Frank, Alberta, a gigantic wedge of limestone 2100 feet high, 3000 feet wide, and 500 feet thick, crashed down from Turtle Mountain. A total of 90,000,000 tons of rock swept over a mile of valley destroying part of the town, taking 70 lives, and burying an entire mine plant in about 100 seconds. The large, light-colored area is covered with rocks. (Alberta Government photo)

sometimes caused also by landslides and by rock slides such as the Frank slide (see illustration page 167). The blasting of rocks with dynamite or TNT, the explosion of an atomic bomb, or any other violent explosion will cause the earth to shake for considerable distances from the location of the explosion.

### How earthquake shocks are detected

Scientists have developed an instrument that will detect vibrations of the earth that are too faint to be noticed otherwise. This scientific instrument is called a *seismograph.* With the aid of a seismograph scientists not only can detect an earthquake but also can estimate its intensity and how far away it is.

You will learn on page 192 how the seismograph is used in searching for oil.

## How volcanic eruptions change the earth's surface

A number of years ago it was believed that all the rock material beneath the earth's crust was in a molten or liquid state. Today geologists agree that although the earth's plastic rock is very, very hot, it is solid, and, regardless of the intense heat, cannot change into liquid because of the great pressure exerted on it by the earth's crust. In some places, however, where a fault in the earth's crust reduces this pressure, the plastic rock may change to molten rock, or *magma.* The magma may be forced to the surface by the weight of the solid rock above it. More often, however, the pressure of gases consisting mostly of steam formed from underground water forces the magma to the surface as a volcanic eruption of hot liquid *lava.*

Not all the magma reaches the surface. Some of it remains below the surface where it cools and solidifies into igneous rock.

When hot liquid lava pours out of the crater or mouth of a volcano, it flows down the outside and spreads out evenly in all directions over the surrounding area where it cools and

Paricutin Volcano, Mexico, is seen in eruption. Note the cone-shaped mountain of lava. To which of the three main types of rock does lava rock belong? How do volcanoes change the earth's surface? (United States Geological Survey photo)

Devil's Tower, Wyoming. This 1600-foot high rock was formed by volcanic action. (United States Geological Survey photo)

hardens into *lava rock*. With each succeeding eruption, more lava is added, until a cone-shaped hill or mountain results. Many volcanic cones are small and some are large. The largest one is the Mauna Loa on the Hawaiian Islands, which rises to a height of 30,000 feet above the ocean floor.

Volcanic eruptions make great changes in the earth's surface. Materials present in the earth's crust are brought to the surface and scattered far and wide; mountains and islands may be built up; cities and towns in the vicinity of active volcanoes may be destroyed. You no doubt have heard that the ancient city of Pompeii in Italy was completely buried by a tremendous eruption of volcanic ash and lava from Mount Vesuvius.

Volcanoes have proved to be an important source of information about the nature of the interior of the earth. By studying the lava and other materials ejected from volcanoes, scientists have learned many things about the composition of the rocks that lie far below the earth's surface. Volcanoes also supply convincing evidence that the interior of the earth must be very, very hot.

**SOMETHING TO DO**

Prepare a report on some of the interesting features of the famous volcanoes of the world. Be sure to include at least one example of each of the three main types — explosive, quiet, and intermediate — in your report.

## Hot springs and geysers

Perhaps it has been your privilege to visit the Yellowstone National Park in the United States. If so, you will have seen many geysers and a variety of hot springs, mud volcanoes, and paint pots. You can, of course, visit

Mount Rainier, in the State of Washington, was formed by volcanic action. Many volcanic mountains in North America are dormant, or inactive. (United States Geological Survey photo)

hot springs in Canada, for example: Miette Hot Springs near Jasper; Sulphur Hot Springs at Banff; Radium Hot Springs, south-west of Banff; and Harrison Hot Springs in British Columbia. It is thought that geysers and hot springs are associated in some way with hot igneous rock at various depths below the earth's surface.

Hot springs may be formed from ground water that has seeped down and become hot by contact with "super heated" steam. Superheated steam is much hotter than ordinary steam. It is produced under pressure, by the heat from the hot igneous rock below the surface. This steam heats the ground water that has run down and forces it to the surface as a hot spring.

The temperature of the water coming from hot springs varies from medium warm to boiling hot. The temperature of the hot spring water at Miette Hot Springs is about 126°F.; at the Upper Hot Springs at Banff, 114°F.; and at Radium Hot Springs, 114°F.

"Old Faithful" geyser in Yellowstone National Park. Boiling water and steam erupt to a height of about 150 feet at regular intervals. What causes the eruption? (United States Geological Survey photo)

These interesting daintily-colored rock formations are located at Mammoth Hot Springs in Yellowstone National Park. Note that the rocks are in the forms of terraces. They were built up from the minerals in the hot springs that flowed down the hillside. (United States Geological Survey photo)

Often deposits of rock-like material such as limestone are formed around the vicinity of a hot spring. Huge formations consisting of these limestone deposits can be seen at Mammoth Hot Springs in the Yellowstone National Park. Sometimes these deposits are quite colorful.

*Geysers* are a spectacular form of hot spring. They erupt from time to

time as gushers of hot water and steam. There are dozens of them in Yellowstone, but the one most widely known is Old Faithful. It erupts at regular intervals of about 65 minutes. The steam and water from it rise to a height of about 150 feet.

Each geyser has a tube, or vent, through which the water and steam move. Because the water at the bottom of the tube is under great pressure, it must be heated above 212°F. before it will boil and change to steam. When the water near the top of the tube boils and spills out, the pressure is reduced on the water below. As a result of the reduced pressure, the superheated water near the bottom suddenly changes to steam and erupts with great force.

#### SOMETHING TO DO

1. Visit one or more of the hot springs to be found in your province. Find out all you can about the origin of the springs, their temperature, the mineral content of the water and its medicinal value, if any, etc. Report your findings to your class.

2. Prepare a report on geysers. Cover such points as: where geysers are found; how they are caused; what they tell us about the earth's interior; etc.

The icicle-like rocks and the pillars in this cave were formed from minerals that were present in the water that dripped down from the roof of the cavern. The rock "icicles" hanging from the ceiling of the cave are called *stalactites.* Those that are built up from the floor of the cave are called *stalagmites.* Sometimes a stalactite grows downward and a stalagmite directly beneath it grows upward until the two meet, thereby forming a pillar. Look for pillars in the illustration. Estimate the diameter of the largest one in feet, assuming that the man standing by it is 6 feet tall. (United States Geological Survey photo)

### TEST YOUR KNOWLEDGE AND UNDERSTANDING

1. What evidence can you give to show that the surface of the earth has changed greatly, and is still changing?

2. What is meant by weathering? Name three weathering agents.

3. Mention four important forces that play a part in the erosion of rocks.

4. Compare a young river valley with a mature river valley with regard to: (1) speed of river, (2) rapids and waterfalls, (3) steepness of side walls of valley, (4) width of valley, (5) number of tributaries.

5. State some scientific evidence to show that in modern times there have been great movements of the earth's crust in different parts of the world.

6. Outline briefly one theory that has been advanced by geologists to account for the formation of mountains.

7. (*a*) Explain how folding of the earth's crust often forms mountains.

(*b*) Distinguish between an anticline and a syncline.

(*c*) What is meant by faulting and slipping in the study of the earth's crust?

8. What is the chief cause of earthquakes? Mention some other causes.

9. How do volcanoes change the earth's surface?

10. (*a*) What is a geyser?

(*b*) What explanation do scientists give to account for geysers?

11. What do volcanoes, geysers, and hot springs tell us about the earth's interior?

## WHAT HAVE YOU LEARNED?

### IMPORTANT SCIENCE IDEAS AND UNDERSTANDINGS

A

1. Geology is the branch of science that deals chiefly with rocks.

2. A geologist is a scientist who can read the story that is written in the rocks.

3. The earth's crust is the outer, solid part of the earth.

4. The earth consists of four layers or spheres: atmosphere, hydrosphere, lithosphere, and barysphere.

5. There are a number of ways in which geologists can estimate the age of the earth.

6. The earth has existed as a planet for about 5,000,000,000 years.

7. Rocks are classified according to how they were formed.

8. Due to the forces of erosion and mountain building, the earth is continually changing.

9. Mountains may be formed by folding, by faulting, or by some other great upheaval of the earth's crust.

10. Depending on their characteristics, river valleys may be young, mature, or old.

11. Volcanoes, geysers, and hot springs all supply evidence that the interior of the earth is hot.

**(a) The foregoing sentences are all true statements of important science ideas and understandings. Read and discuss them carefully as a review of this chapter.**

**(b) The following sentences describe situations in which some of these ideas apply. To test your ability to apply ideas to actual situations, match the sentences in A with situations in B to which they apply.**

**B**

1. Tom Blair visited a nearby river valley. He found that the rocks at the sides and the bottom of the valley appeared to have been worn away. There were smooth, rounded boulders on the bottom of the river bed.

2. When he had successfully completed his grade twelve course, Roger Forbes made plans to go to university to study geological engineering.

3. On her summer vacation, Sharon Kearns went for a swim in the Upper Hot Springs bathing pool at Banff. She found that the water was too hot for swimming, although the manager of the pool said that the water had not been heated artifically.

4. Lillian Barker and Marie Lucas knew by the muddy appearance of the river on which they were boating that it was carrying a heavy load of soil. They tried to picture the change the river was causing by washing soil away from one place and depositing it in another place many miles away.

5. The Saskatchewan River flows quietly as it winds its way across the plains, but the Fraser River rushes along as it gradually cuts a deep gorge through the mountains.

6. High up in the banks of a river, Jim Allison found a rock filled with fossil shells. He later learned that these were the remains of small animals that had lived in the ocean several million years ago. The rock in which the shells were found was also formed at the bottom of the sea.

## IMPORTANT SCIENCE TERMS

A

| | | |
|---|---|---|
| geologist | sedimentary | gneiss |
| lithosphere | metamorphic | marble |
| barysphere | granite | fault |
| erosion | lava | anticline |
| radioactivity | shale | volcano |
| mineral | limestone | earthquake |
| magma | conglomerate | geyser |
| igneous | slate | syncline |

**To show that you understand and can use the science terms listed in A, match with the situations described in B those terms which apply.**

B

1. On the way home from school, Lillian Barker and Marie Lucas walked by a deep cut in a hillside. They observed that the exposed rocks were in the form of layers.

2. John Thompson had made a large collection of the different kinds of rocks to be found in his locality; however, he had difficulty in classifying them, so he asked the help of his uncle who had taken a university course in which he had specialized in the study of rocks.

3. The liquid rock, or magma, that comes to the surface through a volcano, spreads over the surrounding area and forms igneous rock.

4. During the winter months, Jim Allison plays lead on a curling rink that his father skips. The curling rocks that Jim throws are a greyish pink in color. They appear to be made up of a number of different minerals.

5. Scientists have developed a system of "carbon dating" by which they can tell how long ago man carried on certain activities. Any organic material such as wood, bone, or seeds, will reveal its age because of the radiocarbon present in it.

## SCIENCE ACTIVITIES

6. In one of Canada's worst mine disasters (1958), an upheaval of rock within the earth's crust trapped the miners below the surface and caused the death of many of them.

7. John Thompson observed many small cracks in a large boulder. He noticed that the rock material at one side seemed to have shifted its position.

8. Lillian Barker and Marie Lucas were watching a concrete mixer at work on the lot next door where the foundation for a new home was under construction. Lillian observed that after the concrete had hardened, it looked very much like one of the rocks in the collection that she had made.

## SCIENTIFIC METHOD AND ATTITUDES

1. Tom Grant wanted to know how old the Canadian Rockies are. He looked up a number of references and found conflicting information. In one reference the age was stated to be about 300,000,000 years; in another 70,000,000 years; and in a more recent book, 35,000,000 to 40,000,000 years. In which of the following cases would Tom be showing a scientific attitude:

What information does the photograph give you about the rocks on which this lighthouse was built? Where had they been formed? How do you know? What change or changes have taken place since they were formed? (National Film Board photo)

(*a*) If he concluded that geologists do not know what they are talking about and that he might better drop the subject.

(*b*) If he decided to try to find out why these estimates of geologists differ so greatly. Possibly some recent discoveries have changed the opinions of geologists about the age of the Rockies.

(*c*) If he decided to ask a geologist or other authority on this subject to explain these wide differences.

(*d*) If he took the attitude that scientists have no facts to base their opinions on and therefore are just making wild guesses.

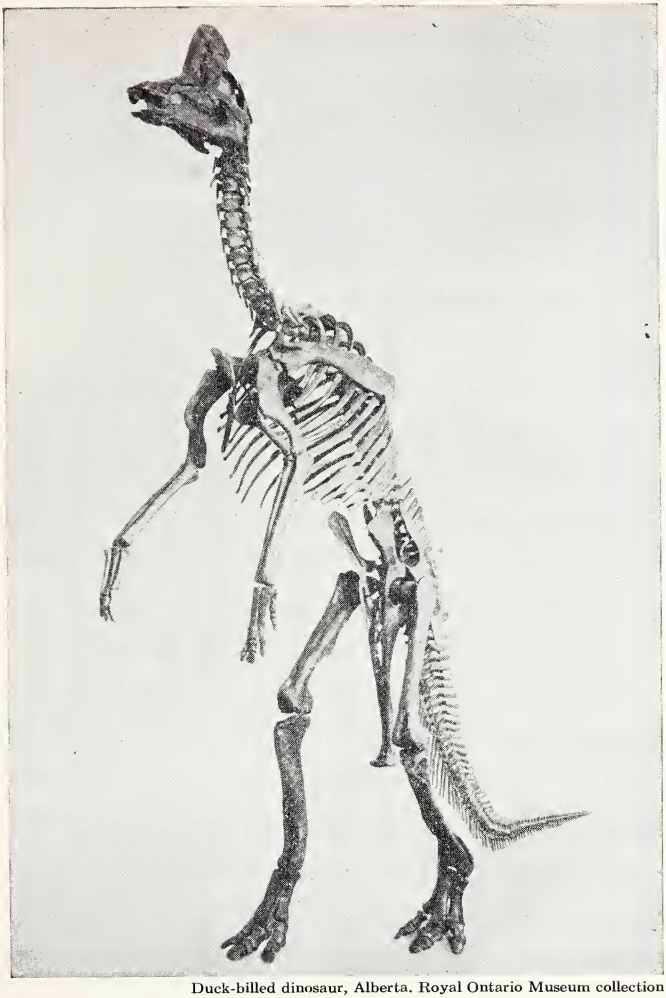
(*e*) If he stopped to consider that although the methods geologists use to determine the age of the mountains result in differences of millions of years, these differences are not great if compared with the 5,000,000,000 years of the earth's history.

(*f*) If he decided that, since geologists do not agree on the correct answer to this question, he should not accept as true any statements made by geologists.

2. Jean Graham was trying to find a test that could be used to distinguish limestone from other kinds of rock. She obtained a piece of limestock rock and dropped some weak hydrochloric acid on it. She observed that bubbles were produced. On the basis of this one test she concluded that limestone can be identified by dropping dilute acid onto it.

(*a*) Do you think that Jean was justified in reaching a conclusion on the basis of the test she made?

(*b*) What improvements would you suggest in her method?



Duck-billed dinosaur, Alberta. Royal Ontario Museum collection

*Rocks are nature's story books. In them is recorded the story of a half-billion years of life.*

—*Selected*

CHAPTER 6

CHAPTER 6

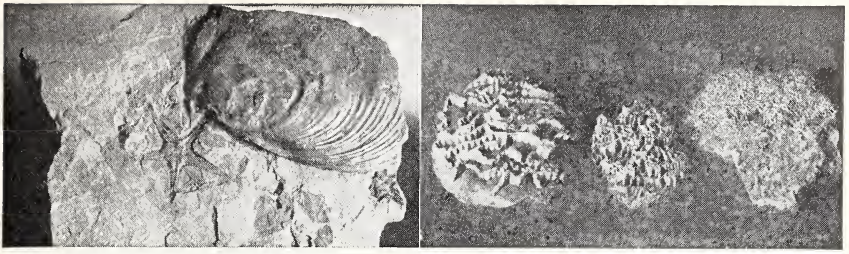
# STORIES IN THE ROCKS

**The rich resources of coal and oil in Alberta and other parts of Canada have been formed from plants and animals that lived millions of years ago. How do scientists know that living things existed long ago? How do geologists use their knowledge of rocks and the fossils in them to discover new oil deposits? Many kinds of dinosaur fossils have been discovered in Alberta. Have you ever gone fossil hunting?**

IT MAY SURPRISE YOU to learn that the land on which your home and your school are built was probably at one time at the bottom of the sea. In fact, almost all parts of Canada have been covered with sea water a number of times. It may also surprise you to know that the land where you live was once about as warm as the tropics are today, and that tropical plants and animals lived on the land and in the warm seas that existed where your province is now. Scientists are able to tell us these and many other interesting facts by reading, from the rocks, stories about living things of long ago.

In the last chapter you learned that the earth is very, very old — probably as much as 5,000,000,000 years old. No doubt you have wondered how long living things — animals and plants — have been on the earth. It is quite easy to learn about life on the earth during the last few thousand years, because man keeps a record of what he does and passes it on from one generation to the next in the form of buildings, pictures, stories, and written accounts of his life. The history of more ancient people can be studied from the buildings they erected, and the pottery, drawings, and tools that they left as evidence of their activities.

However, even the earliest of humans existed only a very short way back in the long, long story of life



Starfish, clams, and various kinds of coral found in Alberta are evidence of the fact that seas covered this part of Canada long ago*

on the earth. Millions of years before man appeared on earth, many kinds of plants and animals developed. Some of them still exist today; many other kinds, both large and small, survived for a few million years, but eventually died out as conditions on the earth's surface changed.

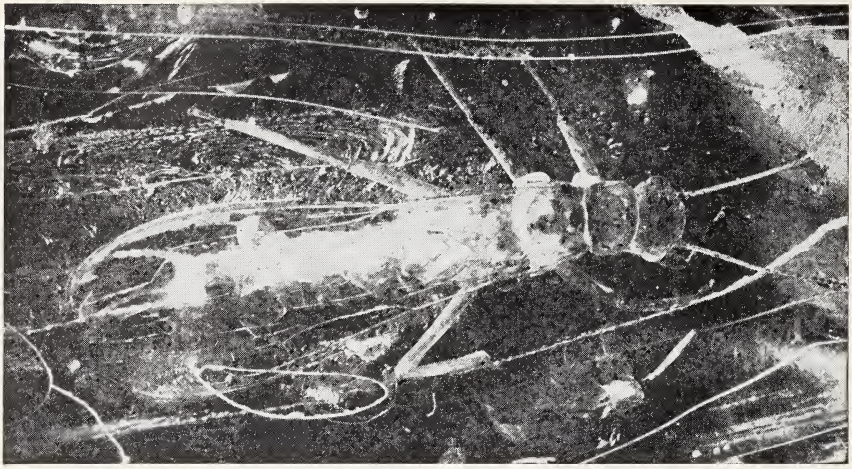
The records of prehistoric life are written in the rocks of the earth's crust. Almost everything that is known about prehistoric life is learned by studying and collecting the remains of prehistoric creatures, usually found as *fossils* in rock layers. The layers of rock are like the chapters of a book. Some pages are blank, showing no evidence of living things; others, like certain layers of rock in the Red Deer River Valley of Alberta, tell of a great variety of prehistoric creatures, both large and small.

Scientists are able to measure, in several ways, the age of various rock layers. Thus they can determine how long ago the fossils in each rock layer existed as living things. By examining and comparing the fossils in many rock layers, scientists are able to trace much of the long history of living things from their early beginnings, millions of years ago, right up to the present. The study of fossils and prehistoric life is called *paleontology*, and the scientists who engage in this study are *paleontologists*.

## HOW FOSSILS ARE FORMED

Most girls and boys have found or seen what looked like a plant stem, or leaf, or perhaps a shell, embedded in a piece of rock. Perhaps you have seen the print of a fern on a piece of soft coal. All these things are fossils. *The remains or impression of any former living thing that has been naturally preserved in rock is called a fossil.*

*Unless otherwise acknowledged, the photographs of fossils in this chapter were taken at the Royal Ontario Museum. The authors are grateful for the assistance of Dr. F. A. Urquhart, Dr. A. G. Edmund, and Mr. D. Cameron, of the Royal Ontario Museum.



An insect perfectly preserved in amber. What parts of it can you see?

No doubt you wonder how fossils get into a rock in the first place. You will recall from the last chapter that the surface of the earth is constantly changing. Some parts are being lifted up. Other parts are being constantly worn down by the action of ice, frost, winds, rain, glaciers, and running water, and the sediment that is worn off is eventually carried by rivers into the sea. Here it settles to the bottom and, in time, forms a thick layer of mud. As sea animals die, their bodies settle to the bottom and are soon covered with sediment. In time, under the great pressure of the water and of more layers of sediment, the mud changes to rock. As we have learned, rocks formed in this way are called sedimentary. The common kinds of sedimentary rocks are limestone, sandstone, and shale. These rocks are the best sources of fossils.

During a period of millions of years, various layers of sedimentary rock are formed, one above the other, by the hardening of the sand and mud on the ocean floor. In each layer are the shells and bony parts of the animals that had been in the sediment that formed the layer of rock.

If you find fossil sea-shells in rock near your home, they probably are evidence that the sea covered your locality at least once, and perhaps several times. Later on, as the surface of the earth changed, your locality was lifted out of the sea. Actually most parts of Canada have been under sea water at various times. Even high up on mountain slopes fossils have been found that must have been formed at the bottom of the sea.

Not all fossils were formed in sea water. Many fossils that are found in rock are the remains of animals and

plants that lived on land. They were preserved when they were covered with soil in some other way. Many of them probably lived in swamps where they were soon covered with water and mud. Many fossils are found in tar pits where they must have become mired. A few insects became stuck in the sap of trees which in time changed into a clear yellowish-colored solid called *amber*.

Petrified wood. Can you see the annual growth rings in this log?

**Kinds of fossils**

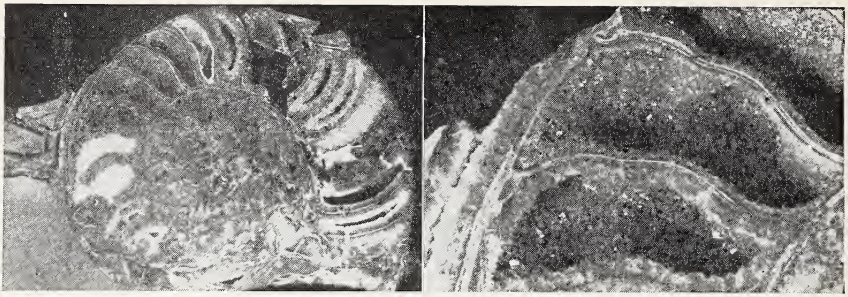
There are four main types of fossils, each formed in a different way. When you collect fossils, you should try to decide how each one was formed.

1. *Actual remains.* Sometimes parts of the bodies of ancient animals are preserved in rock, ice, tar, or amber. The material in the shells of many kinds of shellfish found in limestone rocks may be the same as when the animals were alive. Many prehistoric animals have been found in tar pits with their skeletons almost perfectly preserved. A few years ago, a giant prehistoric animal, a mammoth, was found frozen in ice in Northern Asia. So perfectly was it preserved in the ice that the flesh was edible when thawed out and cooked. Mammoths that were preserved in ice have also been found in Northern Canada and in Alaska.

2. *Petrified remains.* Many fossils, such as petrified wood, look just as they did originally, but are made of rock. The original wood became covered with sediment. Minerals that were dissolved in the water in the sediment gradually replaced the cells of the wood, leaving all the details of the original wood. The bones of most dinosaurs discovered in Alberta have become petrified in this way. In some bones, the porous sections have become filled with minerals.

3. *Fossil molds, casts,* and *prints.* The fossils of many hard-shelled animals are really casts. When the animal died, the soft parts of its body decayed, and the empty space was filled with mud. Later, the mud changed to stone inside the hard covering, making a perfect cast of the original animal. When the cast is removed, the mold, or shape of the fossil, remains in the rock. Sometimes we find prints of ferns in coal. Similarly, the prints of leaves of prehistoric trees are preserved in stone. The leaf has decayed, but the carbon from its cells clearly shows the details of the original leaf.

4. *Fossil footprints.* In some places the tracks of prehistoric animals are found. These unusual fossils were formed when moist soil or mud on

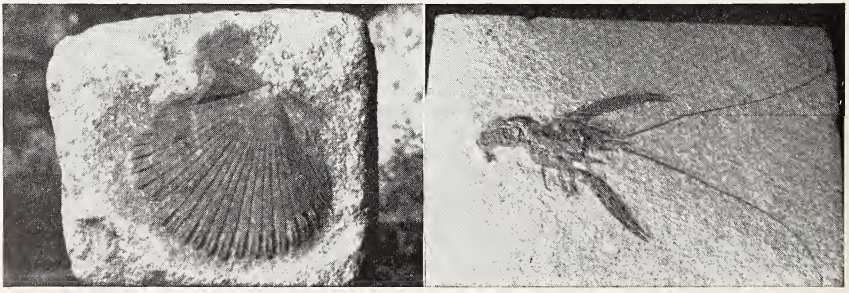


The empty spaces in fossils are usually filled with rock. Some of the cavities in this shell are filled with rock; others are partly filled. In an enlarged view of two of the spaces (right) we can see that they were being filled with shiny, glass-like crystals of quartz.

which the tracks had been made eventually hardened and became rock.

**SOMETHING TO DO**

1. Start now to make a collection of fossils. You can find excellent fossils in lumps of soft coal, or in rocks touching seams of coal, in rock cuts along river banks, in stone quarries, and in places where rock, particularly limestone and sandstone, is exposed at the surface of the ground. In Alberta, there are many good places for collecting fossils. In the Badlands of southern Alberta and in the Red Deer River Valley are many formations containing numerous fossils of dinosaurs and other prehistoric animals. Some of the best fossil-hunting grounds in the world are around Drumheller and Steveville and in the Red Deer River Valley between these communities. By working with other pupils in your class, you will be able to assemble a fine collection of fossils. You might arrange to exchange fossils with a pen-pal in another part of Alberta or in another province.



Some fossil animals that lived millions of years ago resemble modern animals. These two animals lived over 100,000,000 years ago, but they resemble modern crayfish and scallops. Notice that the details of the claws, feelers, and shells have been perfectly preserved in rock.

When a piece of shale that had formed at the bottom of the sea was split open, this ancient animal, a trilobite, was found. On the left is the fossil skeleton of the trilobite; on the right is a mold showing its shape in the rock.

Refer to books about ancient life and geology in identifying the specimens that you collect. A list of useful books is provided on page 211. Many museums also have fossil collections which you may study to learn the names of the fossils that you find. At the Drumheller and District Museum and at the government park near Steveville, you should be able to get help in identifying specimens that you find. Collecting fossils is a hobby that you can continue to enjoy for many years.

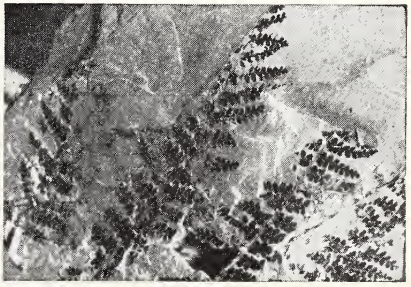
2. Make a cast of a snail, clam, or other shell. Prepare a smooth layer of plasticine or moist clay. Press the shell down into the plasticine or clay. Remove the shell. A mold of the shell remains. Mix some plaster of Paris with just enough water so that the mixture will run. Pour the mixture into the mold. It will harden quickly. When it is quite hard, remove the cast. Does it resemble the original shell? This will help you understand how fossil casts were formed. However, in nature, they hardened into rock very slowly.

3. Make a print of a leaf. Prepare a mixture of plaster of Paris and water, and put it in a saucer. Just before it sets, lay a leaf on the surface and gently press it into the hardening mixture. When the mixture is hard, remove the leaf. Can you identify the leaf by its print in the "rock"?

4. Examine each of your fossils to decide whether it is the actual remains of a prehistoric plant or animal, or is petrified, or is a cast, mold, or print.

### Nature's diary

Layers of sedimentary rock are the pages in the book of the rocks, and fossils tell the story in the book — the story of prehistoric life. The earth's crust is made up of many layers of rock. More layers are constantly being added to the surface. Unless the layers of rock have been disturbed, the top layer of rock was the last to be formed. As we dig down through successive layers, we find older and older rock. Because the bottom layers of rock were formed earlier than the upper layers, we know that the fossils in the deepest layers are of earlier forms of life than the fossils found in more recently formed rock near the surface.



The carbon print of a fern in light-colored limestone rock.

A paleontologist cleaning part of the skull of a sabre-toothed cat (see also the illustration on page 207). This specimen was found in a tar pit. (Ontario Department of Travel and Publicity photo)

In the mountains, or along deeply eroded river valleys, we can see the edges of many rock layers, one on top of the other. The different layers are of different thicknesses and are usually made of different kinds of rock.

On page 185 you will see a time chart of prehistoric life as it is found in the layers of rock in the earth's crust. It is not likely that we could find all of these layers of rock at any one place on earth. However, they all do occur at various places, and by combining all the information we have about rock layers in different parts of the earth, we are able to form a time chart. Each layer is, of course, many feet thick, and the entire depth of all the rock layers that are shown, measuring from the surface down to the bottom layer, would be several miles.

You will see that the time chart is divided into five eras, each lasting many millions of years. These long eras are divided by great changes that occurred on the surface of the earth — rapid warming or cooling, mountain building, or flooding of the land by sea water. As you can see, we have combined the earliest two eras into one, the *Pre-Cambrian* era. Above this are the rocks of the *Paleozoic,* or ancient-life era, which were formed after the Pre-Cambrian rocks. Above the rocks of the Paleozoic era are the rock layers formed in the *Mesozoic,* or middle-life era. The group of rock layers most recently formed and nearest the surface of the earth are those of the *Cenozoic,* or recent-life era. In the remainder of this chapter we shall study and compare life as it appeared and changed during each of these eras.

GEOLOGICAL TIME CHART

| ERA | PERIOD | ROCKS | DOMINANT LIFE | LIVING THINGS |
|---|---|---|---|---|
| CENOZOIC<br>65,000,000 years | | | | "Age of Mammals"<br>Man<br>Modern animals<br>Mastodon, mammoth<br>Cereals, grasses<br>Seed plants |
| MESOZOIC<br>150,000,000 years | CRETACEOUS | | | "Age of Reptiles"<br>Flowering plants<br>Seed trees<br>Cool-forming forests (Alberta)<br>Ammonites<br>Dinosaurs in Alberto<br>Modern insects<br>Small mammals |
| | JURASSIC | | | Early birds<br>Large dinosaurs<br>Flying reptiles<br>Small mammals |
| | TRIASSIC | | | Dinosaurs<br>Flying reptiles<br>Cone-bearing trees<br>First mammals |
| PALEOZOIC<br>350,000,000 years | PERMIAN | | | "Age of Amphibions"<br>Many amphibians<br>Early reptiles |
| | CARBONIFEROUS | | | Cool-forming forests (onthracite)<br>Tree ferns<br>Spore-producing plonts |
| | DEVONIAN | | | "Age of Fishes"<br>Many fishes<br>Many sea animals<br>Origin of Alberta oil |
| | SILURIAN | | | First land plonts<br>First land animals |
| | ORDOVICIAN | | | "Age of Trilobites"<br>First fishes<br>Mony shell animals<br>Sea lilies<br>Cephalopods |
| | CAMBRIAN | | | Trilobites<br>Brachiopods<br>Snails<br>Seoweeds |
| PRE-CAMBRIAN<br>3,000,000,000 years | | | | Small, soft-bodied animols<br>Worms<br>Algae<br>Tiny water plants<br>and<br>onimals |

A geological time chart showing the eras and periods into which the earth's history is divided. At the left are the approximate times at which these eras and periods occurred. At the right are shown and listed some of the more important living things in each period, based on what is found in the fossil records in the rocks. The chart represents only the last 3,500,000,000 years; the total age of the earth is probably about 5,000,000,000 years. (From a drawing prepared by the Royal Ontario Museum)

**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

1. How do scientists know that many parts of Alberta were once covered by the sea?
2. What are fossils?
3. What are the four types of fossils that have been formed?
4. Explain how petrified wood was changed to stone. Why does it still look like wood?
5. Explain why most fossils are found in sedimentary rocks. How did they get into the rocks?
6. In an area where the rock layers have not been disturbed, how do we know that the bottom layers contain earlier life than the top layers?

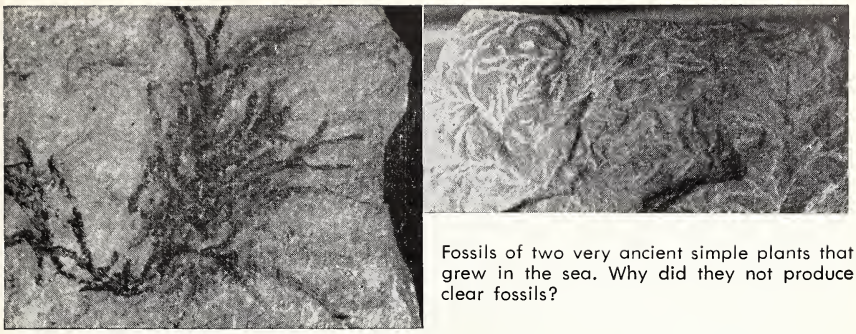
## PRE-CAMBRIAN TIMES

The oldest known rocks in Canada are estimated to be about 2,400,000,000 years old. They are rocks in the Pre-Cambrian, or Laurentian Shield, around Hudson Bay. These rocks are probably about half the age of the earth itself.

In Pre-Cambrian times the surface of the earth that was not covered with water was bare and rocky. There were no trees or other plants. The rocks of the Pre-Cambrian era give evidence of volcanoes, mountain building, and erosion, but there is very little evidence of ancient life to be found. In fact, in the story of ancient life in the book of the rocks, at least the first three-quarters of the pages are blank. In the rocks that were formed during the first 4,000,000,000 years of the earth's existence, there is no fossil record of life. Only toward the end of the Pre-Cambrian era, less than 1,000,000,000 years ago, are the first vague records of life on earth to be found. Although one-thousand million years is only about one-fifth of the probable age of the earth, it is, nevertheless, a very, very long time. To comprehend this great length of time, think about it this way. The time of the giant *dinosaurs*, the prehistoric animals most familiar to us, was about 100,000,000 years ago, a long time indeed. But life probably appeared first about ten times as long ago as the time of the dinosaurs.

### The morning of life

It is not known exactly when the first living things appeared on the earth, but it is thought that life began in the sea, and probably consisted of very simple forms of life. The rocks of the Pre-Cambrian era show no large plants or animals. The fossils that have been found in Pre-Cambrian rocks are of sponges, worms, one-celled animals, casts of worm burrows, and spots which may have been algae,



Fossils of two very ancient simple plants that grew in the sea. Why did they not produce clear fossils?

a simple water plant, very much like green pond scum. It is probable that many other simple animals and plants existed at this time, but as they had no bones, shells, or other hard parts, it is unlikely that many of them would be preserved as fossils. It also is probable that many records of the earliest forms of life have been destroyed by erosion and other changes that have taken place in these rocks since they were formed over 550,000,000 years ago. However, there are enough fossil records to make it clear that life on earth began and existed in Pre-Cambrian times, in the form of simple creatures from which later forms developed.

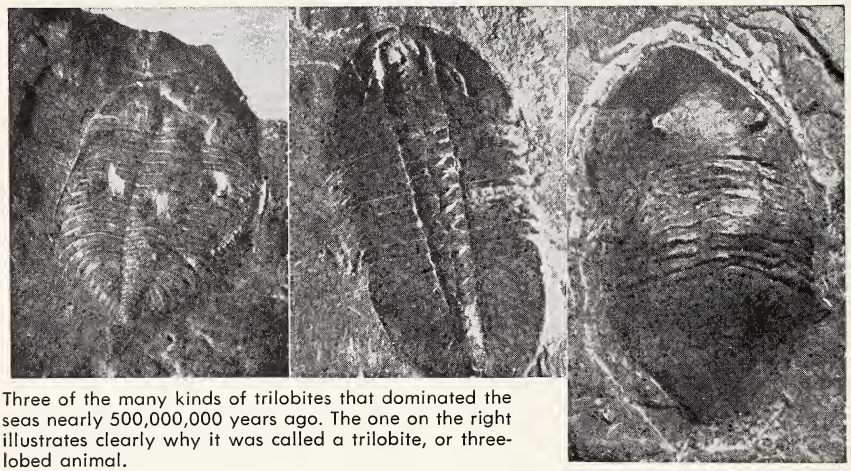
## THE PALEOZOIC, OR ANCIENT-LIFE ERA

About 550,000,000 years ago, the Pre-Cambrian era ended, and the Paleozoic era, or the era of ancient life, began. This era lasted for about 350,000,000 years, or up to about 215,000,000 years ago. (Refer to the time chart on page 185.)

The Paleozoic era was a time of many great changes in the surface of the earth and in the many kinds of life that made their appearance. Several times during this long period the sea covered large parts of Canada, leaving thick layers of sedimentary rock that are rich in fossils portraying the life of the time when they were alive. By studying the formation of the rock layers and of the fossils of this era, geologists have divided the long Paleozoic era into the six *periods,* from the *Cambrian* to the *Permian,* that are shown on the time chart. All of them contain an abundant fossil record.

### The Cambrian period

The commonest and most interesting fossil from the *Cambrian* period is the *trilobite,* a crab-like animal with a hard shell and many legs. Trilobites ranged in size from an inch or less to as long as eighteen inches. The

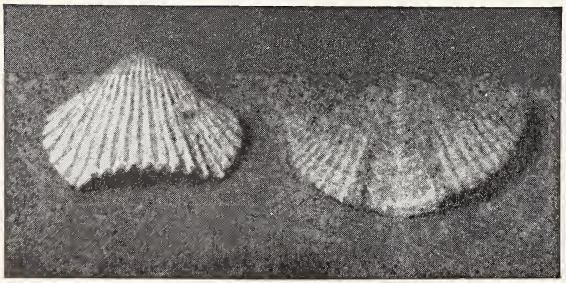


Three of the many kinds of trilobites that dominated the seas nearly 500,000,000 years ago. The one on the right illustrates clearly why it was called a trilobite, or three-lobed animal.

trilobite was named for the three lobes into which the bodies of many kinds were separated. So numerous and wide-spread were these sea animals that they are found in great numbers in Cambrian rocks in many parts of the earth.

The greatest change in animals that occurred during this period was the development of legs, eyes, shells, and hard skins. These developments gave animals better protection and enabled them to move about. The hard parts also provided for clear fossil records, which formed when the animals settled into the sediment on the sea floor.

During this period, it is probable that life existed only in the sea. Besides numerous kinds of trilobites, we find in Cambrian rocks many *brachiopods* and *sponges*, and primitive kinds of *snails*. In addition, there were *worms*, *jellyfish*, and *other soft-bodied animals*. There was probably also an



Brachiopods, common sea animals of the Paleozoic era.

abundance of seaweed, but there are few clear fossil records of it.

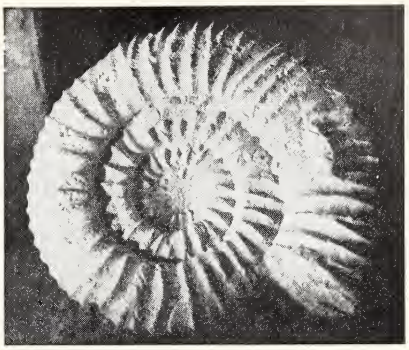
**SOMETHING TO DO**

Because trilobites are common in the Cambrian rocks of many parts of Canada, and because they are among the first distinct fossils, these animals should form part of your individual or class fossil collection. Pupils in the Prairie Provinces may have difficulty finding trilobites, but may be able to trade fossils with friends in Ontario or British Columbia, where many trilobites are found.

Prepare cards to identify your trilobites, brachiopods, and sponges, and show that they are probably from the Cambrian period.

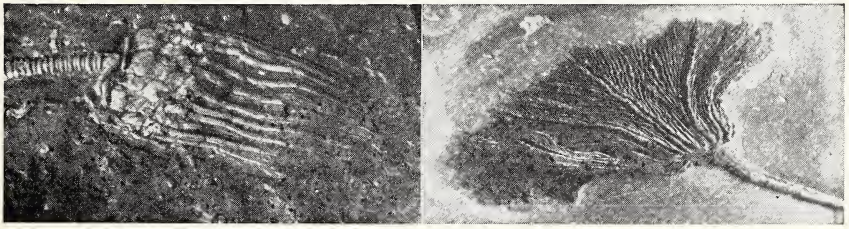
## The Ordovician and Silurian periods

While it is not necessary to remember the names of the two periods, *Ordovician* and *Silurian,* that followed the Cambrian, it is useful and interesting to know about the changes in ancient life that continued to take place in these periods. Hard-shelled animals multiplied in the sea, and new kinds appeared. *Corals* began to build their sea structures. *Clams* and *starfish* developed. The most numerous and remarkable of the new animals were the *cephalopods,* or giant *nautiloids,* fearsome-looking creatures resembling the octopus of modern times, but protected by a shell up to ten feet long (see the pictures on this page and page 190). In some of these nautiloids the shell was straight; in others it was coiled. Partitions in the shell help us identify these animals.

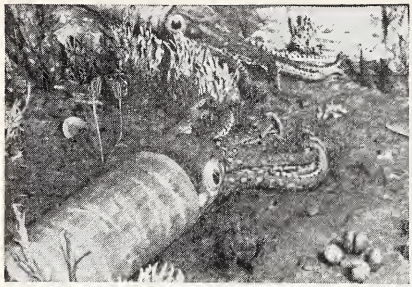


A shell of a coiled nautiloid, another ancient sea animal. This shell is about a foot in width.

By this time numerous seaweeds and other water plants thrived in the sea, but few, if any, land plants had appeared. Besides the true plants in



Are these plants or animals? They are the heads of crinoids, or sea lilies. Although they looked like plants, they were really sea animals. Crinoids were related to modern starfish and were common during Paleozoic times.



In the Ordovician period of the Paleozoic era, large cephalopods became numerous. These were early ancestors of the modern octopus. The word *cephalopod* means head-footed animal. These models are in a display at the Royal Ontario Museum.

the sea, there were many animals with a plant-like appearance. Among the most interesting were the *crinoids*, or sea lilies, like the one on page 189. Although they resembled the flowers and stems of plants, they were really animals.

Up to this time all animals lacked backbones, but during this time the first backboned animal appeared. It was a primitive kind of fish, covered with plates of armor, and lacking moveable jaws. Simple in form as this early fish was, it is very noteworthy, because the development of a backbone was an important step forward in the development of animal life.

A model of an early fish. How was it different from modern fish? Notice the plates on its head and back.

### The Devonian period — the age of fishes

The *Devonian* period is important in the story of ancient life because it was during this period that life spread to the land. Also, it produced one of Alberta's most valuable natural resources in the form of rich deposits of *petroleum* (see page 191).

The Devonian period is often called "the age of fishes" because during this period the number and variety of fishes increased rapidly. By this time fish had developed paired fins. Sharks appeared for the first time. Some fish attained a great size; others developed primitive lungs; others had fins resembling legs.

The first land animal was probably a scorpion-like creature, a relative of the *eurypterid*, shown on page 191. However the first backboned land animals were amphibians, resembling salamanders. These early land-dwellers developed from a type of fish whose muscular fins had become legs. We must remember that all these changes took place very gradually over a period of millions of years.

During the Devonian period, plants moved to the land. The first land plants were seaweeds living along the shores of lakes and seas. Then they spread to drier land and became much larger and sturdier, but most of them still resembled seaweed. They had no

A well-preserved eurypterid, or sea scorpion, about eight inches long. The first animals to emerge from the sea and live on land were probably relatives of sea scorpions.

true leaves, and they produced *spores* instead of seeds. By the end of the Devonian period great forests of these giant plants had spread over some parts of North America. These plants provided food for the animals which were gradually emerging from the sea. Only as plants survived and spread over the land were land animals also able to develop.

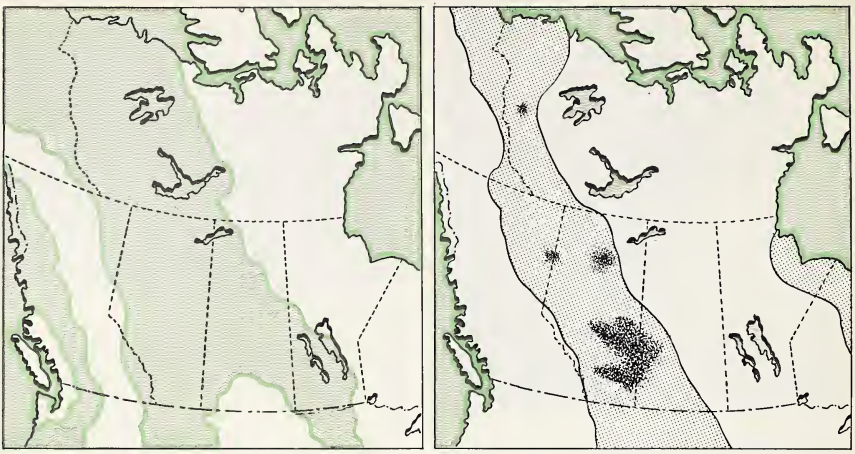
During the Devonian period, most parts of Alberta and Saskatchewan were covered with warm, shallow seas. Here, many kinds of sea animals thrived. Among the largest were clams and *ammonites,* huge snail-like animals with coiled shells. From the picture on this page you will see that ammonites reached an enormous size.

In the warm Devonian seas covering the Prairie Provinces of today, great coral reefs were built. Their existence 300,000,000 years ago is important to us today, because they played a part in producing much of our rich oil supply. By studying the map of the Devonian seas and the map of areas where there are oil deposits, you will be able to see that the Devonian seas were the birthplace of much of Alberta's oil.

### How oil was formed

During the Devonian period, billions upon billions of tiny sea plants and animals lived among the coral reefs in the warm, shallow seas that covered the Prairie Provinces. Many of these living things, especially tiny plants called *diatoms,* had a small amount of oil in their cells. When these plants and animals died, they settled to the bottom of the sea and gradually formed a deep layer of slime. As the seas deposited layers and more layers of sediment on this oil-bearing slime, the increasing pressure and heat changed the oil into *petroleum,* or crude oil. Much of the

The shell of an ammonite. How large is this shell? Ammonites were related to the modern octopus.



Two maps of Western Canada. At the left is shown the area covered by Devonian seas. The dark spots on the map at the right mark existing oil fields. The shaded area is considered good territory for future oil discovery. Why is there a strong similarity in these maps?

oil formed in this way has escaped through the rocks, but in many places the folding of the earth's crust has formed *anticlines,* or dome-like formations in which the oil has become trapped. You will recall learning about anticlines in your study of the earth's crust in Chapter 5.

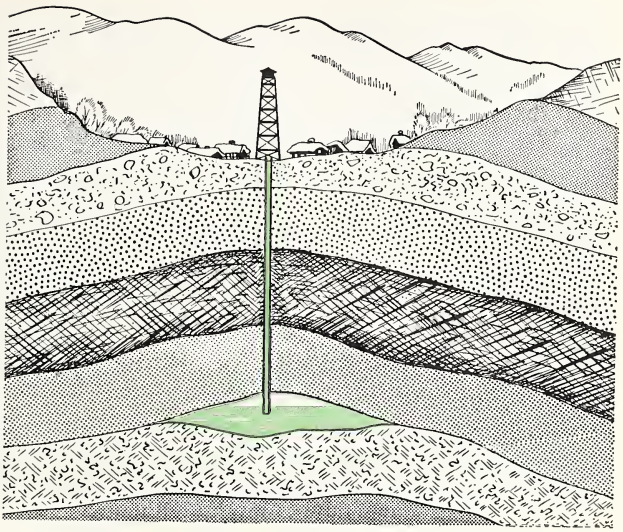
Although most of the oil deposits in Alberta were formed from life in the Devonian period, oil in some other parts of the world was formed from life in other periods as well.

### The search for oil

The rapidly growing demands for oil for heating our homes, providing gasoline for automobiles, lubricating modern machines, and making medicines, fly sprays, rubber tires, soap, waxed paper, and a thousand other products, constantly requires the discovery of new supplies of this precious liquid.

Geologists who seek oil deposits below the earth's surface use many discoveries of modern science to help them. In Western Canada they seek oil over most of the area covered by the Devonian seas. However, to find enough oil in one spot to make drilling worthwhile, they must find a suitable anticline in which the oil may be trapped. The geologist looks for the kind of rock formation that is usually found above an anticline. Often he drills out a *core* which shows the layers of rock beneath the surface.

Another way of finding out if the rock layers are the right kind for trapping an oil deposit is by using a *seismograph,* which, as you learned

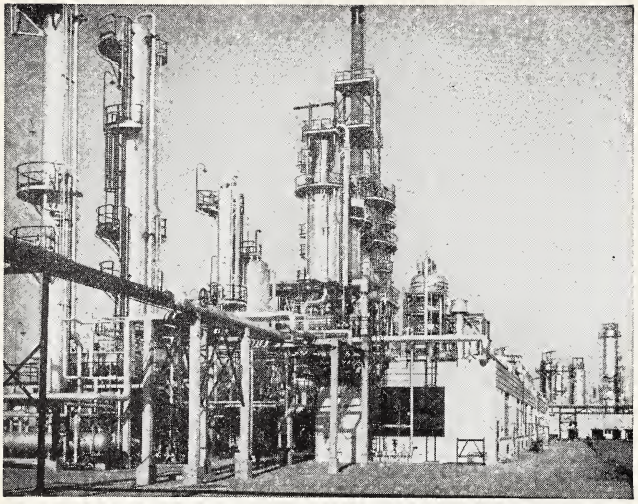


A simplified drawing of an oil well. The arrangement of the layers of rocks is known as an anticline. In such structures oil is frequently found. As shown in this drawing, natural gas is often found above the oil. (From a drawing by Shell Oil Company)

in the preceding chapter, is an instrument for measuring earthquakes. A charge of dynamite is exploded near the surface of the ground, and the seismograph records the shock waves that bounce off each layer of rock. By studying the charts produced by the seismograph, the geologist can determine the structure of the rock layers far beneath the surface. If it

Part of a drill core taken from the rocks far below the surface. How do geologists use drill cores in their search for oil?

A pump at work in the rich oil fields at Leduc, Alberta. (Alberta Government photo)



A large cracking unit at a refinery in Edmonton. In this unit crude oil is "cracked" or separated into gasoline, fuel oil, and other products. (Imperial Oil Limited photo)

is found that an anticline exists below the surface, the geologist may decide that an oil well should be drilled. Even with all the information that the geologist gathers, he cannot be certain that a well will produce oil. In fact, more than half the wells drilled each year prove to be dry.

#### SOMETHING TO DO

1. Locate on a map of your province the areas where rich oil deposits have been discovered in recent years.
2. Watch in newspapers for new oil discoveries in your province.
3. If a search for oil is taking place in your locality, learn what you can about the methods used. Examining a core that has been drilled would help you learn about the rock layers in your area.
4. Try to obtain some corals and ammonites to represent the Devonian period in your fossil collection.

### The Carboniferous and Permian periods

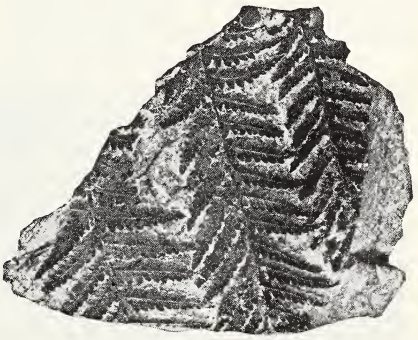
The last two periods in the Paleozoic era, the *Carboniferous* and the *Permian*, were the times when much of the earth's coal — especially hard, or *anthracite*, coal — was formed. In fact, the name Carboniferous identifies it as a time when carbon, in the form of coal, was deposited in the earth. Most of the hard coal of eastern North America was formed from plants of the Carboniferous period, but the soft coal in Alberta and Saskatchewan was formed at a later time.

During the Carboniferous era the sea advanced and receded several times. In many places great swampy forests flourished. Most of the plants were ferns, but they were as large as modern trees. They grew quickly in

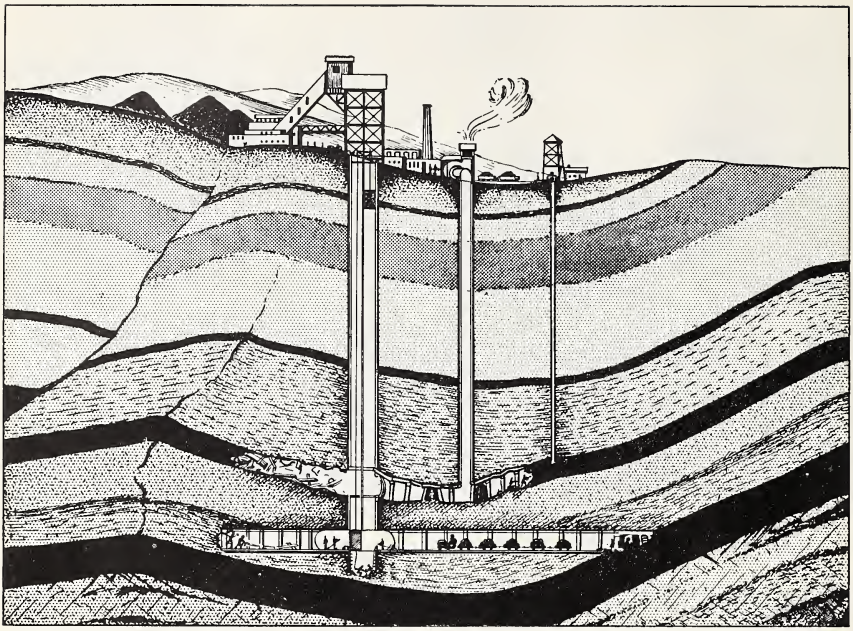
An artist's conception of a coal-forming forest as it grew in Eastern Canada during the Carboniferous period about 200,000,000 years ago. (National Museum of Canada photo)

the warm swamps, and then fell to become part of a thick layer of woody plant matter. Lying under water, they did not decay. When the sea flooded the land, the layer of wood was covered with a layer of sediment. When the sea receded, the swamps flourished again. Thus layer after layer of woody matter was formed, separated, and packed down by layers of sedimentary rock. Time, heat, and pressure gradually changed the woody layers into coal. However, these elements did not erase the story of how coal was formed, because printed in the coal and on the surrounding rocks we find the perfectly preserved shapes of fern leaves and bark. In some coal beds we also find layers of spores by which these early fern-like trees reproduced themselves.

Toward the end of the Permian period other types of trees began to appear. Among them were the first cone-bearing trees, somewhat resembling modern evergreens.

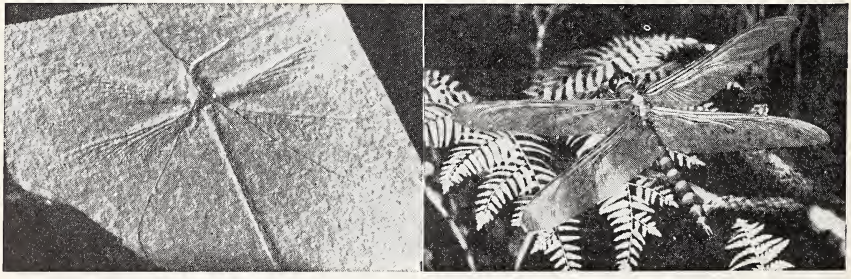


A fern-leaf fossil taken from a coal mine in eastern North America. Notice how perfectly the leaf pattern has been preserved. (Norfolk and Western Railway photo)



A cross-section of a coal mine. Explain why there are several layers of coal. What evidence can you find to show that there have been movements in this part of the earth's crust?

Animal life, too, continued to change and develop during these two periods. Most of the trilobites disappeared from the sea. Crinoids, or sea lilies, continued to survive in great numbers. On land, the earliest amphibians gave way to larger and more varied forms. The swamps of these



A fossil (left) and a model of a giant dragonfly (right) from the Carboniferous period. Some of these insects were over two feet in width! (Left, Royal Ontario Museum; right, Chicago Natural History Museum)

A drawing of life late in the Paleozoic era, about 200,000,000 years ago. The fin-backed reptiles were related to the ancestors of modern mammals. The other animals are amphibians. (Chicago Natural History Museum)

times were ideal places for such animals, which, like frogs, toads, and salamanders of today, spent part of their life in the water. Some of these amphibians reached a length of eight feet.

At this time, insects first appeared in the fossil records. Some of them resembled the dragonflies of today, but were much larger, with a wingspread of more than two feet.

Toward the end of the Paleozoic era, conditions on earth changed greatly. Mountain ranges began to appear, and the climate became drier and colder. As these conditions changed, other changes took place in living things. Only the hardiest kinds of plants and animals survived. New kinds of animals developed under the changing conditions. The most important of the new animals that appeared were the *reptiles,* which were to become so varied, so large, and so numerous, that the next era is often called "the age of the reptiles."

#### SOMETHING TO DO

1. Try to find pieces of rock or coal that contain fern fossils.
2. Compare pieces of hard coal (anthracite) and soft coal (bituminous). Find out why these two types of coal are different.

#### TEST YOUR KNOWLEDGE AND UNDERSTANDING

1. Pre-Cambrian rocks contain very few visible fossils. What are the probable reasons for this apparent lack of fossils?
2. Describe a trilobite.
3. Why is it easier to read fossil stories from Cambrian rocks than from Pre-Cambrian rocks?

4. What changes in certain kinds of fish enabled them to develop into land animals?

5. Why is the Devonian period of special interest to residents of Alberta?

6. From what, and how, were deposits of oil formed?

7. Describe a coal-forming forest of the Carboniferous period.

## THE MESOZOIC ERA — THE AGE OF REPTILES

The Mesozoic era, or middle-life era, began about 215,000,000 years ago and ended about 65,000,000 years ago. From the fossil records of this time it is clear that this era was dominated by reptiles — on the land, in the sea, and even in the air.

As you can see from the time chart on page 185, the Mesozoic era is divided into three periods. During the first two of these, reptiles developed many forms, and continued to change and multiply in the third period, the Cretaceous. The Cretaceous rocks of Alberta, especially those exposed by erosion in the Red Deer River Valley, contain a wealth of reptiles from the Cretaceous period.

As the face of the earth changed and the seas were pushed back by the rising mountains late in the Paleozoic era, the amphibians began to disappear. Some returned to the sea where they developed along many lines. Some of these slowly changed into turtles which have survived with little change until today. Others developed into fish-like reptiles; others resembled lizards with long necks. In most of the sea-dwelling reptiles, the legs became fins and flippers. We must remember that all these changes took place very, very slowly. Some changes required millions of years. However, the fossils in the rocks of this time show clearly that these many changes developed in the animals of this time.

### The dinosaurs

It was on land that the most remarkable changes in the reptiles occurred, for it was here that the giants among the reptiles developed. Some of the amphibians continued to survive as the swamps dried up. From these there developed small, agile reptiles which, during the passing of millions of years, changed into the *dinosaurs* or "terrible lizards," which included the largest and most fearsome animals that ever travelled across the face of the land.

The dinosaurs varied greatly in size, from animals weighing a few pounds to the giant *Brontosaurus*, a sluggish plant-eating monster seventy feet long, that probably weighed thirty tons! In between there were many other kinds of dinosaurs of different sizes, appearances, and habits.

Some of the dinosaurs ate plants; others hunted and ate other animals.

Several kinds of dinosaurs. Find Stegosaurus (plated dinosaur), Allosaurus (a meat-eater), and Brontosaurus (the thunder lizard). What types of plants were most numerous?

Many of the plant-eaters lived in whatever swamp-lands they could find, where the water helped them support their great weight. Others lived on land, and, like the *Stegosaurus* shown on this page, developed rows of bony plates as a form of armor. It is thought that most of the plant-eaters, such as the Brontosaurus and Stegosaurus, were clumsy and dull-witted, for in spite of their great size they had very small brains.

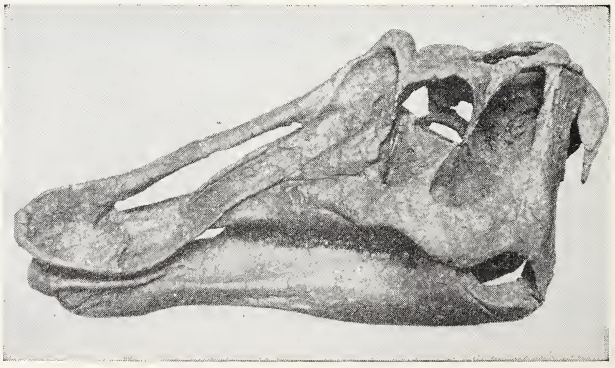
The fossil records of several kinds of plant-eating dinosaurs are found in Alberta. The most numerous are the duck-billed dinosaurs, which, as

A scene from the Cretaceous period. Find the following: Tyrannosaurus (giant meat-eater); turtles; duck-billed dinosaurs; Triceratops (three-horned dinosaur); pterosaurs (flying reptiles). Notice that broad-leaved trees had also developed by this time.

A duck-billed dinosaur in Cretaceous rock, found near Drumheller, Alberta. Using the shovel as a guide, determine the length of this giant reptile. Compare it with the duck-billed dinosaur on page 177. (National Museum of Canada)

the name suggests, had no teeth in the front of their mouths. Instead, they had a large beak, shaped like that of a duck. They chewed their plant food with special plates consisting of hundreds of teeth, which were located farther back on their jaws. Many of the duck-billed dinosaurs also had peculiar hollow crests, or projections, some of which were more than three feet long, growing from the tops of their heads. The purpose of these crests is not known. Some of the duck-billed dinosaurs discovered in Alberta were thirty feet long and fifteen feet tall (see pages 177 and 201).

Another type of plant-eating dinosaur had a short, heavy body, a head armed with horns, and a bony frill over the neck. These horned dinosaurs also had numerous cheek teeth for grinding their plant food.



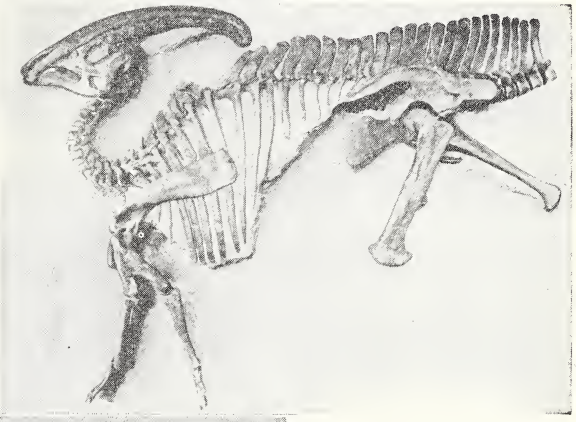
Detail of the three-foot-long skull of a duck-billed dinosaur from the Red Deer River Valley, Alberta. Notice the numerous teeth.

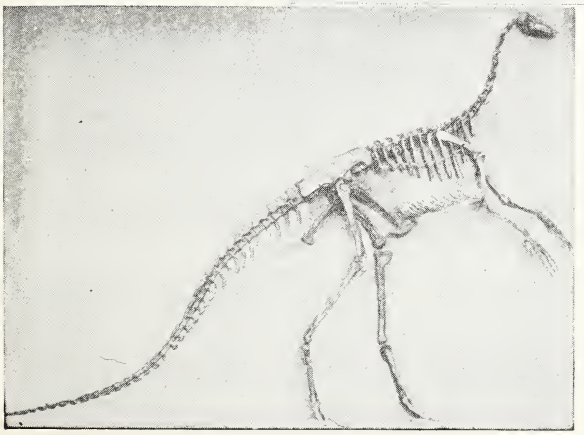
Alberta dinosaurs from the Cretaceous period.

Above: A 20-foot-long horned dinosaur with a protective frill.

Left: Edmontosaurus, a duck-billed plant-eater, 25 feet long.

Right: Part of a crested dinosaur.





Left: An ostrich-like dinosaur that ran on hind legs that were 6 feet long.

Less numerous, but just as unusual, were the dome-headed dinosaurs. These creatures had a tiny, walnut-sized brain, which was protected by three inches of solid bone. Another group, the *Ankylosaurs,* managed to survive because they were protected by bony plates and a club-like tail.

Among the most agile of the dinosaurs were the ostrich-like types. These lightly built creatures had hollow bones and no teeth. Although they were reptiles, they probably lived very much as ostriches do today.

The meat-eating dinosaurs were the scourge of life in Mesozoic times. These swift-moving predators varied greatly in size. The greatest of them all was the *Tyrannosaurus,* "the king of the tyrant lizards." This powerful beast stood twenty feet tall and over forty feet long. With its great mouth, armed with numerous six-inch teeth, the Tyrannosaurus probably feared no animal, and feasted on any creature that it could catch.

### Flying reptiles and early birds

As the great variety of dinosaurs was developing on land, a number of them also took to the air. Their forearms became leathery wings that enabled them to glide through the air. Some of these *pterosaurs,* or flying reptiles, were the size of a crow; others attained a wingspread of nearly thirty feet!

The flying reptiles had no feathers, so, of course, were not birds. However, the first birds did appear at this time. On page 203 you can see one of the first birds that developed. Like the reptiles, from which it probably developed, it had teeth and a long tail, but it had taken the first big step toward being a bird; it had grown feathers. Although a few other birds also appeared about this time, bird skeletons from this period are among the rarest of fossils.

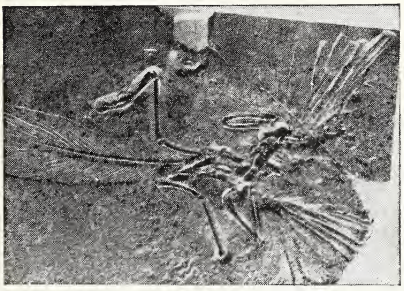
A well-preserved skeleton of a pterosaur, or flying reptile. Notice the beak-like mouth and long, fine bones that supported the wing membranes.

#### SOMETHING TO DO

1. Examine the pictures on the preceding pages of fossil skeletons of dinosaurs that once lived in Alberta. The skeletons were uncovered chiefly in three parts of Alberta: in the Red Deer River Valley from north of Drumheller to near Steveville; along the Milk River; and along the South Saskatchewan River near Medicine Hat. If you have a chance to take a trip to the Red Deer River Valley, you may be able to find dinosaur bones which have been uncovered and left there by people who have been searching for nearly complete skeletons. In some places the dinosaur bones are very numerous.

2. If you live in or near Calgary, or will be visiting it soon, you should plan to see some of the life-size models of dinosaurs on display in St. George's Island Park.

A group of Archaeopteryx, with two small dinosaurs and some flying reptiles. (From a painting by C. R. Knight, courtesy Chicago Natural History Museum)



Fossil remains of an Archaeopteryx, the oldest bird yet discovered. Can you locate the wings and the large tail feather? Why do feathers not make very clear fossils?

3. Check encyclopedias and the books on prehistoric animals listed on page 211 for pictures of these Mesozoic creatures:

DINOSAURS: Allosaurus; Brontosaurus; Stegosaurus; Triceratops; Tyrannosaurus; armored dinosaurs; duck-billed dinosaurs.

FLYING REPTILES: Pterodactyl, Pteranodon.

### Other changes in Cretaceous times

The great number and variety of dinosaurs of the Cretaceous period was its most exciting feature, but something else happened at that time that is far more important to us today. It was during the Cretaceous period that plants began to flower and produce seeds. Maples, poplars, oaks, willows, and many other plants that live today appeared at that time, and are commonly found in Cretaceous sandstone. Aided by insects, wind, and water, seed-bearing plants quickly spread across the land. The development of seed-bearing plants was important because most birds and mammals which had not yet developed depended for food either directly or indirectly on seed-producing plants.

The Cretaceous period also provided many of the coal beds in Alberta

These rod-like fossils, often bearing a delicate pattern, are commonly found in Cretaceous deposits in Alberta. They are the shells of baculites, which were ancient water animals.

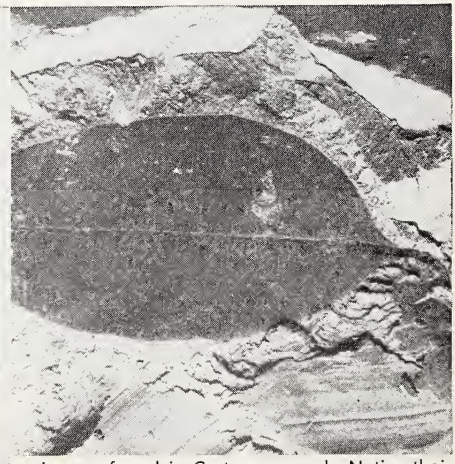
and Saskatchewan. The *bituminous*, or soft coal, formed during this period is not as hard as the coal which formed in earlier times in eastern North America. Most of the Alberta coal deposits were formed from flowering trees and other plants. The great thickness of these coal beds, and the wide area they cover, give us some idea of the great forests which once covered parts of today's prairies. Some of the oil deposits of Western Canada were also formed during the Cretaceous period.

#### SOMETHING TO DO

By examining lumps of soft coal or rocks touching seams of coal, you may find a leaf print from an early seed-bearing tree of the Cretaceous period. This would make an interesting addition to your fossil collection.

### The dinosaurs disappear

After developing into a great many kinds of dinosaurs of many sizes and with many forms of special equipment, the giant reptiles that dominated the earth in Mesozoic times completely disappeared from

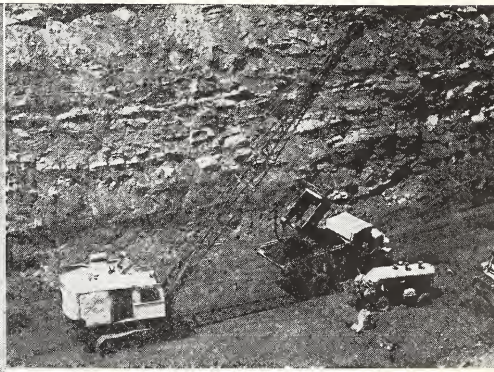


Leaves found in Cretaceous rock. Notice their similarity to modern leaves. Alberta's bituminous coal was formed from similar leaves and the wood of the trees on which they grew.

the earth. The story of why they became extinct is not clearly recorded in the book of the rocks. It may be that the land dried up or that the climate became too severe for these cold-blooded reptiles. Perhaps the plants that they needed for food began to die out in the changing climate. Many scientists think that the reason the dinosaurs disappeared was because a new group of animals began to develop and compete with the dinosaurs. These were the *mammals* — smaller, faster, quick-witted, warm-blooded animals that were able to withstand the changing climate. It is possible that the mammals hastened the disappearance of the dinosaurs by finding and eating their eggs and young. In any case, the giant dinosaurs vanished, leaving only their fossil remains as proof of the fact that they once lived, thrived, and ruled the land for a hundred million years.

**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

1. Why is the Mesozoic era called the "age of reptiles"?
2. What evidence is there that dinosaurs once lived in Alberta?
3. Briefly describe one kind of dinosaur.
4. How did the earliest birds resemble reptiles? How were they different from the flying reptiles that lived at the same time?
5. What important change in plants occurred during the Cretaceous period? Why was this an important development?



Bituminous coal formed in the Cretaceous period lies near the surface in some places. Left: Drilling into a layer of rock that covers a bed of coal at Blairmore, Alberta. Dynamite will be discharged in the holes to blast off the surface rock. Right: Open pit coal-mining in Crowsnest Pass. (Alberta Government photos)

## THE CENOZOIC ERA — THE AGE OF MAMMALS

The closing of the age of the reptiles was marked by great changes in the earth's crust. During this era, which started about 65,000,000 years ago, the continents rose out of the sea. The Rocky Mountains began to push upward, and gradually reached their present height. Volcanoes developed in many parts of the earth. As the seas receded, our continent took its present shape.

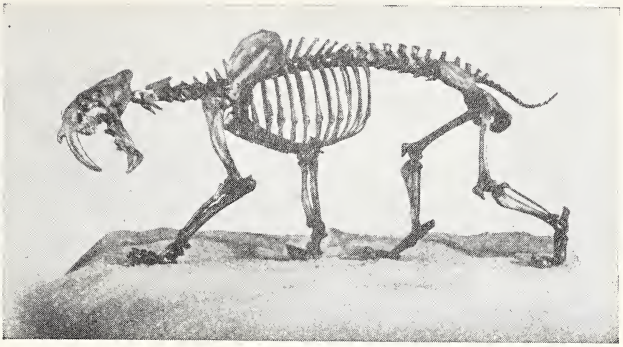
The Cenozoic era, or recent era, is also known as the age of mammals, for it has been only in the past 65,000,000 years that the mammals, including man, have taken over the earth. During the days of the dinosaurs, there were only a few kinds of small mammals. However, as the dinosaurs disappeared, and as new plants developed for food, mammals increased greatly in number and in kind.

The most important of the new plants that appeared were the members of the grass family. This new group of plants provided food for a host of larger mammals as they appeared, and later on supplied cereal grains for man himself.

The story of the development of mammals, like the stories of other ancient life, is read from the fossils in rocks. Because these rocks are most recently formed, and are thus nearest to the surface in most places, the development of the mammals can be traced quite clearly by the scientist.

The Prairie Provinces contain a wealth of fossils of early mammals. As the Rocky Mountains gradually

This bird lived about 40,000,000 years ago. From its beak and bone structure you can see that it was similar to modern birds.



This skeleton of a sabre-toothed cat, often incorrectly called a sabre-toothed tiger, was found in a tar pit where it had become trapped many thousands of years ago. Notice the wide mouth and giant fangs.

rose, erosion was constantly at work wearing them down. The sediment was carried down to the plains by rain and wind, forming a deep deposit in which animal remains were buried. In the rich, warm forests and grasslands such mammals as mice, rabbits, and hares, early dogs and cats, primitive deer, horses, cattle, pigs, and many others prospered and gradually changed until they reached their present forms.

### Ancient horses

The story of how horses have developed is a good example of the many changes that took place among mammals during the Cenozoic era.

The history of the horse family can be traced in great detail from the numerous fossils found in Cenozoic deposits in western North America. The first animal recognized as an ancestor of the horse was the size of a small dog. It probably lived in the forest where it fed on leaves. Its teeth were small, and, as it had such a short neck and muzzle, it probably did not eat plants that grew on the ground. *Eohippus,* as this early horse is called, had four toes on each front foot, and three toes on each hind foot. Although each toe had a small hoof, the animal probably walked flat-footed.

As millions of years passed by, the descendants of Eohippus became larger, and the number of toes on each foot was reduced. In the grassy prairies that first appeared about 40,000,000 years ago, horses found a new food supply. To chew the tough grass, they developed long, hard teeth that could stand a great deal of grinding. To escape their enemies, horses gradually developed the one-hoofed foot, an efficient mechanism for running. Eventually the horse reached its present form, in which it was common in many parts of North America. Some of these animals crossed to Asia on a land bridge joining Alaska and Asia, and there they flourished and spread to many parts of Europe and Asia. Strangely enough, all the horses in North America had died out long before the white man

Some animals found in a tar pit in California. Find a wild dog; teratornis (the largest flying bird that ever lived); sabre-toothed cats; and early horses. This group of animals lived less than a million years ago. (From a painting by C. R. Knight, courtesy Chicago Natural History Museum)

came. However, early explorers brought with them descendants of the horses which had migrated to Asia and Europe. These and later imports were the ancestors of the domestic and wild horses found in North America today.

**The ice age arrives**

About a million years ago, a series of great changes again marked the face of North America, and greatly changed the animals living here. The climate began to grow colder, and the tropical plants dried out. Great glaciers, made of thick layers of ice, appeared in the north and gradually spread in all directions, covering almost all of Canada, as you will see from the map on the opposite page. It is estimated that in places the glaciers were three-quarters of a mile thick. As these great masses of ice pushed forward, the animals that had thrived in the warm climate of earlier times died out, changed in form, or were driven ahead of the ice. New animals developed that were able to withstand the cold. Horses, camels, and other animals escaped to Asia across the land bridge formed between Alaska and Asia. Across this bridge came many new kinds of animals. One of them was the giant woolly *mammoth,* resembling a huge, hairy elephant, that came to live among the glaciers of Northern Canada.

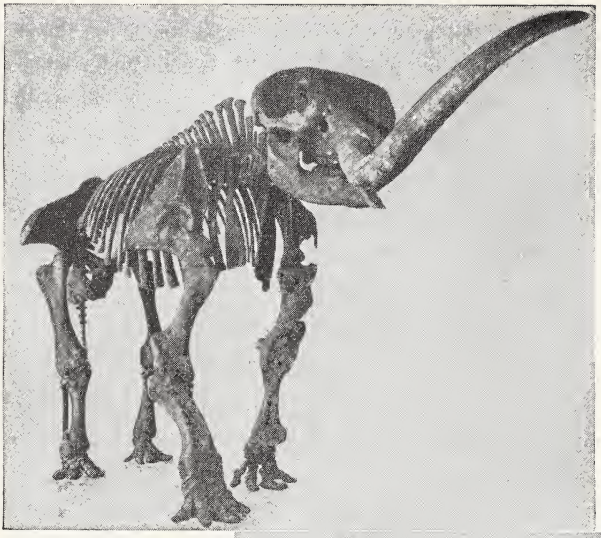
A similar, but larger, animal was the *mastodon* (see page 210). These monsters roamed all across North America and have been found in many places from Alaska to Florida.

In time the first ice age began to wane as the glaciers melted. As the glaciers withdrew, animals again moved to the plains. Thousands upon thousands of years passed, but again the land cooled, and again the great glaciers moved across the land, covering it with ice, grinding rocks, rounding off the tops of hills and mountains, carving valleys and lakes, and causing rivers to form. Four times in all, glaciers covered much of North America, and four times they melted away. The last of the great glaciers

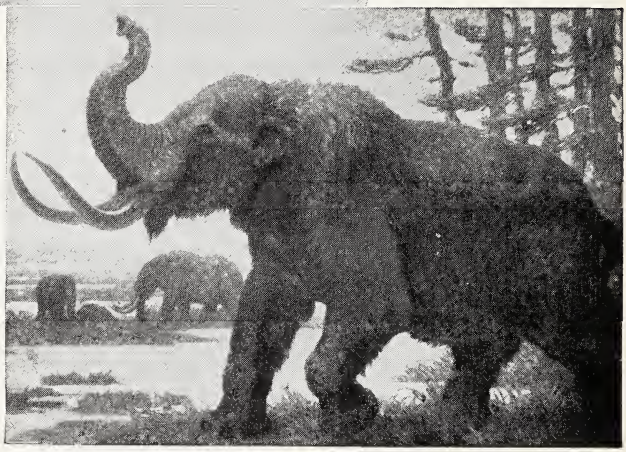
North America during the Ice Age. Notice that the glaciers moved outward in all directions from two centres on the mainland of North America.

covered most of Canada about 40,000 years ago, and is still gradually melting away in the far north and in the Rocky Mountains.

In the thousands of years between the invasions of the glaciers, mammals continued to appear and develop. Some, like the giant mammoths and



A skeleton of a mastodon, the commonest of the huge elephant-like mammals that lived in North America during the Ice Age. In the skeleton one of the giant tusks is missing. (From a painting by C. R. Knight, courtesy Chicago Natural History Museum)



A drawing of a mastodon, reproduced from a painting by C. R. Knight. (Courtesy Chicago Natural History Museum)

mastodons, giant wolves, and sabre-toothed cats, died out completely. Others, like the horse, gradually changed until they reached their present size. Other mammals, like rabbits, hares, and mice, remained more or less unchanged over the years.

**Early man**

Everyone who learns about ancient life wonders what the rocks tell about early man and how long human life has existed on earth. Unfortunately, the complete story of early man is not yet known. At present, the

evidence indicates that man has probably lived on earth less than a million years, a very short time in the long history of the earth. Most of the oldest evidences of human life came from Europe, Africa, and Southern Asia. We know that Indians have lived for a very long time in North America, but scientists have not yet been able to determine whether they were here before the beginning of the last ice age.

The modern age is called the *Epoch of Man.* Although man lacks the great size and strength of the dinosaurs and of many mammals of yesterday and today, he has become the master of his surroundings. His larger brain and superior intelligence enable him to make life easier and safer. He has learned to use tools and fire, to herd and use other animals, and to plant and harvest crops. He can record history and pass it on to his children. He can study the world he lives in, can plan for the future, and by reading the records in the rocks, can figure out and gradually piece together the long and fascinating story of the development of life on earth.

**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

1. What great changes took place on the surface of North America during the Cenozoic era?
2. How did the glaciers affect animal life during the Cenozoic era?
3. Briefly describe two mammals that lived in Canada between the glaciers, but that have since disappeared.

**SOMETHING TO DO**

1. In our study of stories in the rocks it is not easy to understand the very great amount of time involved. For example, it is difficult to imagine how long a million years is. Think about it this way. Suppose we let a very long piece of string represent time, and that we used one inch on the string to represent 100 years. A million years would have to be marked 10,000 inches, or about one-sixth of a mile, along the string! Figure out how far along the string we would mark the time when the trilobites lived (500,000,000 years). How long would the string have to be to represent the present estimate of the total age of the earth, which is about five billion years?

2. The books that are listed in the footnote at the bottom of this page* are a few of many that would be helpful to

**Animals of Yesterday: Stories Read from the Rocks* by B. M. Parker (Toronto: Copp Clark Company); *The Dinosaur Book* by E. H. Colbert (Toronto: McGraw-Hill); *The First Book of Prehistoric Animals* by A. Dickinson (Toronto: Ambassador Books); *The Fossil Book* by C. L. and M. A. Fenton (Toronto: Doubleday); *The Golden Treasury of Natural History* by B. M. Parker (Toronto: Musson Book Company); *Let's Read about Prehistoric Animals* by K. Ware (Toronto: Longman's Green); *The World We Live In* by Lincoln Barnett (Toronto: Musson Book Company) and *The World We Live In,* junior edition, by Lincoln Barnett (Toronto: Musson Book Company).

you in your reading and study of ancient life. Try to obtain several of these books from your school or public library. Prepare a short report on the development of a group of plants or animals that is of interest to you. For example, you might write on dinosaurs in Alberta, on the history of horses, or on early mammals of the prairies.

3. If possible, add some fossils and bones of prehistoric mammals to your fossil collection. Try to identify all your fossils.

4. Arrange the fossils in your collection into groups, depending on the era in which they lived. Keep improving your collection in the future by adding new fossils to it.

## WHAT HAVE YOU LEARNED?

### IMPORTANT IDEAS AND UNDERSTANDINGS

A

1. The story of ancient life is read from fossils in the layers of rock forming the earth's crust.
2. Fossils may be actual remains of ancient life, or may be petrified, or may be casts, molds, or fossil prints and footprints.
3. The earliest living things were very small and simple in form, but as time went on larger and more complex forms developed.
4. Most parts of Canada have been covered by the sea many times.
5. Very few fossils are found in Pre-Cambrian rocks, such as those in the Laurentian Shield around Hudson Bay.
6. During the Paleozoic era, shellfish were the dominant animals, but many larger animals, including fish, also developed.
7. Much of Alberta's oil was formed from sea life of the Devonian period.
8. The Mesozoic era was dominated by reptiles, some of which were the largest land animals.
9. Much of the coal mined in Alberta was formed from seed-bearing trees that developed during the Cretaceous period.
10. At the beginning of the Cenozoic era, about 65,000,000 years ago, mammals became the dominant animals.
11. During the last million years, Canada's surface and animal life have been affected by the glaciers of several ice ages.

(a) The foregoing sentences are all true statements of important science ideas and understandings. Read and discuss them as a review of this chapter.

(b) The following sentences describe situations in which some of these ideas apply. To test your ability to apply ideas to actual situations, match the statements in A with sentences in B to which they apply.

B

1. In rocks touching seams of soft coal in southern Alberta, Jim Allison found several prints of leaves similar to those of trees living today.

2. While searching for oil in southern Alberta, geologists sometimes find corals in the drill cores.

3. In their fossil collection, Miss Peterson's class has several corals and sea-shells that were found high in the Rocky Mountains.

4. When several pupils visited the Red Deer River Badlands with their teacher, they found a large bone, shaped like a spool. They learned that it was part of the backbone of a dinosaur.

5. In some ancient rocks found in northern Ontario, the pupils were shown traces of carbon that may have once been tiny sea plants.

6. Among your fossils you may have pieces of rock that show clearly the rings and cells of wood.

**IMPORTANT SCIENCE TERMS**

A

| | | |
|---|---|---|
| fossil | Paleozoic | cephalopod |
| sediment | Mesozoic | anticline |
| paleontologist | Cenozoic | bituminous |
| dinosaur | Devonian | anthracite |
| trilobite | Cretaceous | pterosaur |
| Pre-Cambrian | amphibian | mammoth |
| mastodon | mammal | glacier |

To show that you understand and can use the science terms listed in A, match with the statements in B those terms which apply. Two or more terms may apply to some of the sentences.

B

1. A man from an oil company came to Mr. Shaw's farm to see if the rock structure indicated a possible source of oil.

2. In studying a mural showing life of 100,000,000 years ago, Sharon Kearns was surprised at the size of the giant lizards and the flying reptiles.

3. In a stone quarry some boys found, in a piece of shale, a fossil of a flat sea animal with a body divided into three parts. The boys learned that the shale had been formed nearly 400,000,000 years ago from material that had settled to the sea bottom.

4. In a report on natural fuels, it was stated that Alberta's oil and coal were formed during two different periods of time.

5. In comparing coal samples, scientists learned that the coal mined in Nova Scotia is usually harder than Alberta coal.

6. In a large museum, Ben Olson saw skeletons of two prehistoric mammals of North America that resembled elephants.

## SCIENTIFIC METHOD AND ATTITUDES

1. John Thomson was interested in reading about prehistoric animals, and made a good collection of fossils. However, it seemed to him almost unbelievable that the plains of Alberta had once been covered by the ocean. One day an oil company drilled deep into the earth's crust near John's home. John visited the drilling site to examine the cores that were removed from deep in the earth's crust. In one of them he saw fossils of corals, snails, clams, trilobites, and seaweed. John realized that these must once have lived in water that covered this part of the land.

How did John show the scientific attitudes of curiosity and open-mindedness in his study of fossils?

2. Finding new ways of measuring accurately the age of rocks and the fossils in them has been one of the difficult tasks of geologists and paleontologists. These scientists must be open-minded about the age of rocks and of the earth itself, and have from time to time changed their ideas as new facts were discovered. For a long time people thought the earth was about 6000 years old. At the beginning of this century a scientist calculated, from the rate that salt is added to sea water, that the earth is 100,000,000 years old. In 1930 several geologists found rocks that they calculated to be at least 2,000,000,000 years old. Recently scientists have learned to tell the age of rocks by changes that take place in radioactive materials in the rocks, and in this way have estimated the earth's age at about five thousand million years, or five billion years. In what way do these statements indicate that the men studying the age of the earth show a scientific attitude? Do you think that further changes will be made in our estimates of the age of the earth? Why?

M. Kesterton

*The soil is not only the foundation of agriculture, but it is also the basis of all human prosperity. It is one of the most common, and yet one of the most precious things in all the world.*

*—Harris and Stewart*

# CHAPTER 7

CHAPTER 7

# THE SOIL THAT FEEDS US

What is soil? Some soils are "rich" and others "poor." What makes the difference? How were soils formed? Soil is one of our most important natural resources. Why? How may the fertility of our soil be conserved and maintained for future generations? What methods are used by the farmers in your locality to conserve the moisture in the soil?

Following a field trip that her class had taken to gather samples of different kinds of soil, Miss Peterson told the girls and boys that John Burroughs, a great naturalist, once said, "Had there been no soil, had the rocks not decayed, there had been no you and I." This led to a discussion by the pupils regarding the importance of the soil to us.

"I think the statement is right," said Tom. "People have to eat to live, and everything we eat comes from plants that grow in soil."

"That's only partly true," declared George. "When you eat meat, eggs, and cheese, or drink milk, you are getting your food from animals, not plants. However, I can see that if you eat fruit, bread, or vegetables, you are eating plant products."

Mary now joined in the discussion. She said that the beef cattle, the dairy cows, and the hens that give us these foods feed on grass and grains that were nourished by the soil. She maintained that it is true, therefore, that "the soil feeds us."

Jean recalled that in a science lesson some months ago, some of man's basic needs had been listed as food and water, clothing, and shelter. "Soil not only feeds us, but it also helps to clothe and shelter us," she said. This led to further argument, but Jean stood her ground.

"Much of our clothing is made of cotton and linen fibres obtained from plants. Warm clothing for winter is made of wool. Wool comes from sheep, and sheep feed on plants, which, in turn, are nourished by the

The soil nourishes the grass and other crops on which these dairy cattle feed. Using this food, the cows manufacture the milk that supplies us with important items in our daily diet. (United States National Dairy Council photo)

soil. Therefore, the soil helps to clothe us," Jean said.

It was not difficult for all the members of the class to see that still another of man's basic needs, shelter, is largely a product of the soil. They knew that lumber is the most widely used material for building homes. They knew also that lumber is cut from trees that have used the plant foods present in soil in order to grow to maturity.

"Since soil is so important to us, farmers, gardeners, and others should do everything possible to conserve it for future generations," they agreed.

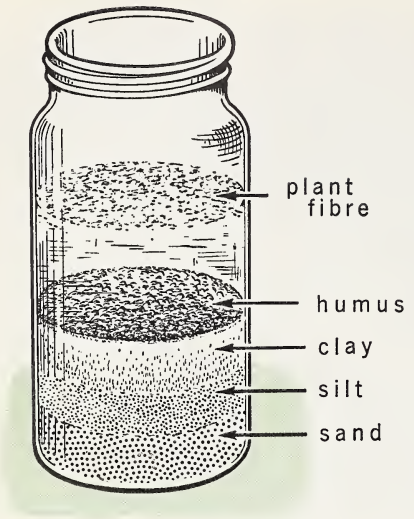
"You are quite right," said Miss Peterson, "and let us all remember that a fertile soil helps to make people prosperous."

## LOOKING AT SOIL

The best way to learn about soil composition is to examine some samples.

### SOMETHING TO DO

1. Spread samples of soil thinly on a sheet of paper. Examine them closely with a magnifying glass. Does the soil appear to be composed of tiny pieces of rock? Look closely at these rock particles. What colors are they? Are some red, green, black, grey, white? Some shine like glass; others are dull. Note that the particles vary greatly in size. The




Experiment to separate soil into layers of different sized particles.

coarser grains are called *sand,* the next in size are *silt,* and the very fine particles are *clay.* But soil is not composed entirely of rock particles. If you look closely, you will find, scattered throughout the sand, silt, and clay, specks of a black, softer-looking material. This is *humus.* It is formed by the decay of plant material, such as roots, stems, leaves, etc., and animal matter.

2. Put about a three-inch depth of garden soil in a tall, slender bottle. Add water to bring the contents to within an inch or two of the top. Cover the mouth of the bottle and shake it thoroughly until the soil is well mixed with the water. Allow to settle. Now look for layers of coarse particles (sand), medium-sized particles (silt), fine particles (clay), and black specks of softer-looking material (humus). Where do you find each layer? Make a drawing to show what you observed.

3. Heat to a very high temperature a small sample of garden soil in a tin lid or in another suitable container. What happens? The part of the soil that burns is the *humus.*

After you have burned out all the humus, what does the remaining material look like? The part of the soil that does not burn is *pulverized rock.* It is composed of sand and clay.

You should remember, then, that soil is a mixture of sand, clay, and humus.

The examination of the soil samples and the results of the experiment performed have shown you that soil is not composed of sand alone, or of silt, or clay, or humus alone, but that it is a mixture of all four. Therefore, we say that *soil is a mixture of sand, silt, clay, and humus.* Most of the soil particles come from broken-down rock material. They are red, yellow, green, black, or white in color. In addition to rock particles and humus, a fertile soil contains water, air, and bacteria and other living things.

## Types of soil

As has been stated above, soil is composed of sand, silt, clay, and humus. The amounts of each of these materials present in a soil varies greatly in different parts of the country.

### SOMETHING TO DO

1. To find out for yourself about the different types of soil, arrange a field trip to gather samples of sandy soils, clay soils, and loam soils. Farmers and

gardeners will be able to tell you where to look for these different soil types.

Put each sample in a labelled glass jar and keep for your soil experiments or as a permanent collection.

2. For information about *soil zones* in your province, write to your provincial Department of Agriculture for a copy of a pamphlet that contains a soil zone map. Study the map carefully. What are the chief soil zones? In which soil zone is your school located?

Soils that contain a large amount of sand, very little clay, and usually only a small supply of humus are called *sandy soils.* Such soils do not hold water very well, and often are lacking in fertility.

Soils that are composed chiefly of clay with small amounts of sand and humus are known as *clay soils.* Farmers refer to clay soils as "heavy land" because they are often sticky and difficult to work. In actual weight, however, clay soils are lighter than sandy soils. Clay soils have great water-holding capacity. After a heavy rain, a clay soil often forms a thick, hard crust on top.

*Loam soils* are composed of various amounts of sand and clay, and large quantities of humus. They are dark in color, fairly easy to work, and excellent for growing most kinds of crops.

NOTE. — There are many variations of the three main types of soil, such as sandy loam, silt loam, and clay loam.

### Topsoil and subsoil

As the name would suggest, *topsoil* is the top layer of soil. It is dark in color and usually about four to eight inches deep. This is the part of the soil that farmers and gardeners cultivate and in which they sow seeds to grow crops.

Directly beneath the topsoil is the layer called *subsoil* (*sub* means *under*). The subsoil may be two or three feet or more in depth depending on the locality. It is usually grey or reddish-brown in color.

#### SOMETHING TO DO

Examine a cut bank along a road, a gravel pit, an excavation for a building, or a ditch (see illustration page 220).

Find the dark top layer (topsoil) and the light-colored lower layer (subsoil).

In which of these layers do you find the greater number of roots growing?

Look closely to see if there is a sharp dividing line between the two soil layers.

Observe whether the subsoil is composed of fine grey clay particles or loose coarse material. This will vary with the locality.

It is estimated that over 90 per cent of the feeding roots of plants are found within six inches of the surface. When these die and decay, humus is added to the soil. The humus gives to the topsoil its dark appearance. It also helps to make the topsoil fertile and to improve the soil in other ways as well.

The nature of the subsoil is important in crop production. Gravelly subsoil, for example, permits moisture to escape too readily. Also it is lacking in fertility. A clay subsoil holds water

Pupils and teacher on a field trip to study topsoil and subsoil. From carefully observing this cut bank, they have found that the dark topsoil is only about six inches deep. (Conservation Branch, Ontario Department of Planning and Development photo)

very well. It contains a good supply of minerals which can be taken into plants through the roots that grow down into the subsoil.

By adding humus to subsoil, it is possible gradually to change it to topsoil. This process as carried on by nature is a very slow one. It has been estimated that between 100 and 1000 years are required to produce one inch of topsoil.

### How has our soil been formed?

Miss Peterson's class learned that the soil feeds us and helps to clothe and shelter us as well. They learned,

also, that soil is made up of decomposed rock and decayed plant and animal matter. At the beginning of their science lesson Miss Peterson remarked: "You have learned what soil is and how important it is to us. Do you know that at one time there was no soil? Millions of years ago the earth's crust was solid rock."

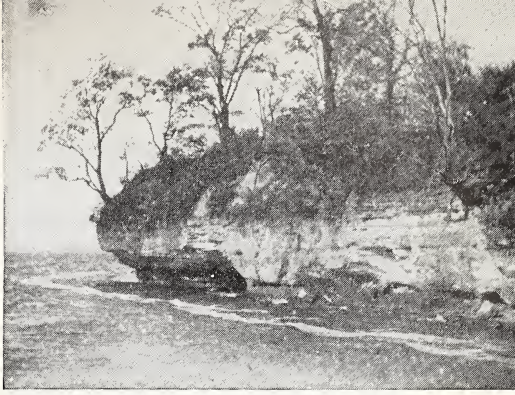
"That's a surprise to me," admitted Tom Grant. "I just took it for granted that our soil was always here. I never stopped to think that it had to be formed."

"I used to believe the same as Tom," commented Mary McLean, "until I read in a book that for centuries and centuries, glaciers, water, and other agents have been wearing away the surface of rocks into fine particles. As a result, a layer of this extremely fine rock material has been formed. This makes up the most of our soil."

"It would be interesting to learn more about this," suggested Norma Hudec, and the class agreed.

Miss Peterson admitted that she had been hopeful that the class might decide to make a careful study of the ways in which our soil was formed. "Such a study will lend itself to a number of interesting activities such as experiments, reading, and field trips," she said.

The pupils decided that the main topic would have to be divided into sub-topics. Each pupil, or a group of pupils, would then be expected to gather information about one small topic and report back to the class.



Notice how the water has *eroded* or worn away the rocks along this lakeshore. (United States Geological Survey photo)

"All of you should understand clearly," cautioned Miss Peterson, "that although each of you will be reporting on only a small part of the whole problem, all will be responsible for learning the important ideas brought out in all the reports."

With this understanding clearly in mind, the pupils went to work to find the answer to the main problem: *How Has Our Soil Been Formed?*

## How does water aid in soil formation?

Roger Forbes and Harold Parsons volunteered to do some experiments in the next science period. The other members of the class, of course, would be expected to observe the experiments as the boys performed them. They would carefully note the results and assist in arriving at conclusions. Also they would try to apply the facts learned in an effort to find the answer to the problem being studied.

### SOMETHING TO DO

1. Fill a small bottle (such as an ink bottle) with water and screw the top on.

Freeze out-of-doors or in a refrigerator. What happens when the water freezes? When water changes to ice why does it exert pressure? What do you think would happen if water should get into cracks in rocks and freeze there?

2. Put a teaspoonful of salt into a tumbler of water. Stir. Does the salt disappear? What property of water is illustrated by this experiment? Heat some of this solution in a clean dish or glass beaker until all the water evaporates. Observe that a white deposit is left behind. Taste it. What is it?

3. Obtain a small limestone rock. Using a hammer, crush it into fine pieces. Put some of this pulverized limestone into a glass container and cover it with pure water. Does anything happen? Next add some diluted hydrochloric acid or vinegar to the water and stir well. What happens? Does water with some acid in it eat away rock?

The pupils learned from these and other experiments previously performed that water expands when it freezes. They learned that ice occupies more space than the water from which it came. Therefore, when water in a closed bottle or a tin container changes to ice, a very great force is exerted. This force is great enough to crack the radiator of an automobile or the water pipes in a home. They reasoned that when water seeps into cracks in rocks and freezes there, the pressure exerted breaks the rocks apart.

Roger said that he had read in a science book that "freezing water exerts a pressure of 2000 pounds per square inch." This is a very great force. After it has been applied over and over again, the rocks are gradually broken into smaller and smaller pieces. Therefore the freezing of water in cracks in rocks is an important aid to soil formation.

The pupils also learned from their experiments that some substances dissolve readily in water. Therefore, when water comes in contact with rocks, it dissolves certain salts or minerals out of the rocks, thereby causing the rocks to crumble into small particles.

When carbon dioxide gas dissolves in water, an acid is formed. If this acid seeps into cracks and pockets in limestone rock, the limestone is slowly dissolved just as it was in the experiment.

"Running water also is an agent of soil formation," Ruth Osmak stated. "In fast flowing streams and torrents it wears away rocks along its channels. It carries large rocks along and wears them into round, smooth boulders. As the streams reach the lower levels of their channels, where they flow more slowly, the finely pulverized rock particles settle out of the water to form *deltas*, such as those formed at the mouths of the Mackenzie, the Fraser, and the Mississippi Rivers."

### How does changing temperature affect rocks?

Helen Smith and Mary MacLean reported on the affect of changing temperature on rocks. They recalled from previous study that solids ex-

pand when heated and contract when cooled. Rocks, being solids, therefore expand when heated and contract when cooled. "Temperature changes," Helen said, "can cause rocks to break apart."

Mary MacLean related her experience of pouring hot water into a cold glass tumbler. The glass had cracked. She explained it in this way: "First of all, the hot water caused the inside of the glass to expand rapidly. The outside of the glass did not expand so rapidly, because glass is a poor conductor of heat, and the heat from the hot water did not reach the outside of the tumbler very readily. This *unequal expansion* between the inside and the outside of the tumbler resulted in a very great strain — sufficient to crack the brittle glass."

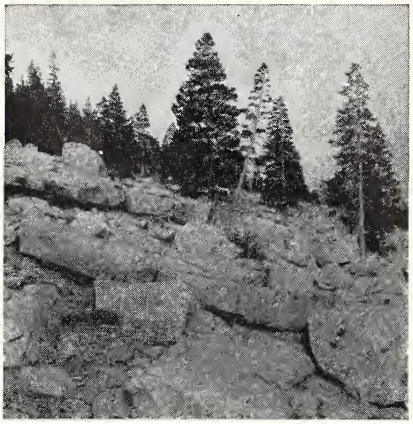
"Rocks behave like glass," Mary continued. "They crack when their surfaces are rapidly heated. They also break when their surfaces are rapidly cooled."

Helen said that she and Mary would try some experiments to show how changing temperature affects rocks.

#### SOMETHING TO DO

1. Heat a piece of window glass until it is very hot, then plunge it suddenly into very cold water. What happens when you do this?

2. Heat a small piece of slate-like rock in a flame until it is very hot, then drop it into cold water. What happens? Repeat the experiment using different kinds of rocks. Does the rapid cooling of a hot rock cause it to break?



These granite rocks have been broken and loosened by frost. (United States Geological Survey photo)

The pupils discussed the results of the experiments, and arrived at the conclusion that the sudden cooling of a heated rock causes the rock to crack and chip.

Miss Peterson asked them how this would help to break down mountain rocks to form soil. They decided that on a hot summer's day the sun would heat the outside of the rocks and cause them to expand much more than the inside. This *unequal expansion* would cause a great strain and if repeated day after day would slowly chip the rocks away.

During the day when the rocks are hot, often a cold shower of rain cools the surface of the rocks suddenly. This causes the outside of the rock to contract more rapidly than the inside. Such *unequal contraction* also exerts a strain sufficient to break the rock. The same thing happens when,

following a hot day, the air suddenly becomes cool at nightfall.

After a rock has been cracked or chipped by this unequal expansion or contraction, it is more readily acted on by other agents of soil formation.

**How do glaciers break down rocks?**

Edith Brown and Jean Wilson undertook to prepare a report on glaciers. They looked for information in the school encyclopaedia, and also recalled what they had learned about glaciers in Chapters 5 and 6. Edith commenced the report:

"Glaciers are 'rivers of ice.' They are formed on mountain sides. The snow piles higher and higher until its weight exerts sufficient pressure on the lower layers to change the snow to ice. Finally the weight of this snow and ice becomes so great that it loses its balance on the mountain side and slowly moves downward owing to the pull of gravity."

She said that glaciers move very slowly. The fastest move a few feet a day, and the slowest, a few inches a day.

"It usually happens that large rocks become frozen into the underside of the glacier," Edith continued. "As the glacier moves slowly along, these rocks are crushed and broken. So also are the rocks along the path of the glacier. Sometimes scratches and grooves can be found in rocks over which glaciers travelled long, long ago. These glaciers aid in breaking down rock into soil materials, and in transporting and mixing these into soils. In places, the glaciers have scooped out large hollows which later have become filled with water to form lakes."

At this point Jean took over the report. She told the class what she had read about the Ice Age, a time when most of Canada was covered by a great slowly-moving ice sheet or glacier. Jean quoted from a book as follows: "Geologists believe that there were three or four ice ages. The first ice age began about a million years ago when the earth's climate became colder. Masses of ice forming the ice sheets reached thousands of feet in thickness and exerted a pressure of over one hundred tons on each square foot of ground or rock. Later, when the climate began to get warmer, the southerly parts of the glaciers began to melt. As the glaciers melted and receded, piles of loose rock of all sizes, pebbles, and smaller soil particles were left behind. Oval-shaped hills, gravelly knolls, and *moraines* consisting of rough, very stony land were formed by glacial action. Such deposits are known as *glacial drift.* In some places these deposits are several hundred feet thick. Later some of the smaller particles were scattered widely by glacial streams. Streams flowing away from the ice sheet carved deep, broad valleys such as the Qu'Appelle in Saskatchewan, and the gorge at Niagara Falls."

Miss Peterson asked if any members of the class had ever visited the Columbia Ice Fields on the Banff-

Top: Columbia Ice Fields, Alberta, showing a glacier. Centre: Deep grooves in rocks that were gouged out by glacial action. Bottom: Glacial drift, a mixture of rocks and soil that was transported and deposited by a glacier long ago. (Geological Survey of Canada photos)

Jasper highway in Alberta. Fortunately, Jack and Edith Hopkins had motored with their parents to Jasper on their summer vacation. They had spent half a day at the Ice Fields and were pleased to be able to tell their classmates about them.

"The Columbia Ice Fields are very interesting," Edith said. "The glaciers that make up the Ice Fields belong to the Ice Age. They are a million years old. Each year the main glacier recedes about fifty feet, leaving a pile of rock behind it. We travelled all over this huge glacier in a snow-

mobile from which we got an excellent view."

Miss Peterson added: "Many other glaciers also can be seen from the Banff-Jasper highway. These glaciers, together with the rugged mountains, gushing waterfalls, fast-flowing rivers, highly colored lakes, towering forests, and beautiful wild flowers, all add greatly to the enjoyment of this very scenic mountain drive."

### Planning a field trip

"Since it may not be possible for all of us to visit a glacier, as Jack and Edith were able to do, I suggest that we plan a field trip on which we shall look for evidence of glacial action and glacial drift in our locality. Perhaps we should look for the results of other agents of soil formation, as well," said Miss Peterson.

The class jumped at the opportunity of being able to make some first-hand observations out-of-doors. They knew, however, that *if a field trip is to be successful, it must be carefully planned.* With Miss Peterson's guidance, they compiled the following list of things to look for:

1. Glacial drift.
2. Scratches or gouges in rocks made by glaciers.
3. Weathered rocks.
4. Rocks with lichens and mosses growing on them.
5. Earthworm castings.
6. Rocks or cement sidewalks broken by growing roots.
7. Evidences of wind erosion.
8. Evidences of water erosion.
9. Soil from woods or bluffs to compare with soil from open fields.

Some of these items would be found by the pupils in their own school yard. For others it would be necessary to look farther afield.

### How does wind help to form soil?

On the field trip taken by her class, Joan Graham saw drifts of soil in ditches and against the fences along the roadway. Gail Oliver reported finding some old implements in a farmyard almost covered with fine soil. They informed their classmates that this was evidence of *wind erosion.* High winds often carry great quantities of surface soil from cultivated fields. When this happens, great clouds of dust may be whipped up into the air causing a "dust storm."

Joan explained that there is another way in which winds affect soil formation. "When a wind blows sand against a rocky surface, the rock is slowly worn away. The result is the same as if the rock were given a light sand-papering. This weathering effect, over a period of hundreds of thousands of years, becomes an important factor in changing rocks into soil."

### How do plants help to form soil?

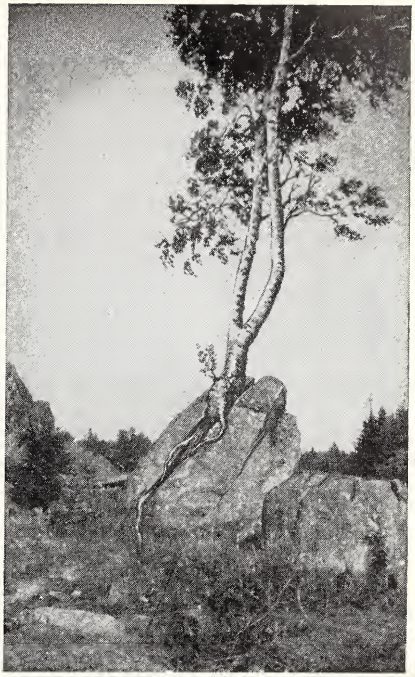
"We compared a sample of soil from a bluff with soil from an open field," reported Ben Olson. "We found that the soil from in among the trees contained much more humus than the field soil."

"Why should that be?" asked John Thomson.

"Well," answered Ben, "I think the decayed leaves, stems, and roots of trees and other plants over a period of many years would add a great deal of humus to the soil. You will recall that we have already learned that humus consists of decayed plant and animal material."

Roy Kendal had something further to report. He said that he and Ben had found some rocks on which small, simple, non-flowering plants called *lichens* were growing. Although the lichens were mostly grey in color, some were red, rust, purple, blue, or brown. They scraped off the lichens and examined the surface of the rocks underneath them. They found the rocks to be quite pitted and rough. It seemed to them that the lichens had been feeding on some of the materials present in the rock. That was why the rocks were rough.

"You are quite right," said Miss Peterson. "Lichens and mosses give off acids from their roots. These acids dissolve certain minerals present in rocks, then they are absorbed into the roots again. In this way they gradually get a foothold on the rocks. When these small plants die, some humus is formed. Again other small plants take root, flourish, and die, thereby making more soil. Finally, there is enough soil for tree seeds to germinate in a crevice in the rock. Thus, in a few years, a tree may be seen growing on a mountain cliff or from some other rocky surface."



The tree root growing in this rock exerted enough force to split the rock wide open. (United States Geological Survey photo)

Still another way in which plants aid in soil formation was mentioned by Ronald Shaw. He said that he had seen a rock that had been cracked wide open by a root of a pine tree growing in it. This would expose more surface to the weathering agents, such as water and wind, and thereby speed up the formation of soil.

### What part do animals play in soil formation?

The last report on soil formation was presented by Rita Kusior and

One big weed will use a barrel of water from the soil during its period of growth. Why is it poor practice to allow weeds to grow in our fields and gardens?

Ruth Osmak. They had found earthworm castings on the school lawn. Also, following a heavy rain they had seen large numbers of earthworms crawling over the lawn and garden.

"Earthworms help to mix the soil materials into soil," Rita stated. "Sometimes the earthworm is referred to as 'nature's greatest ploughman.' It makes a network of tunnels through which air circulates. As we have already learned, air is essential for the germination of seeds and for the work of beneficial bacteria."

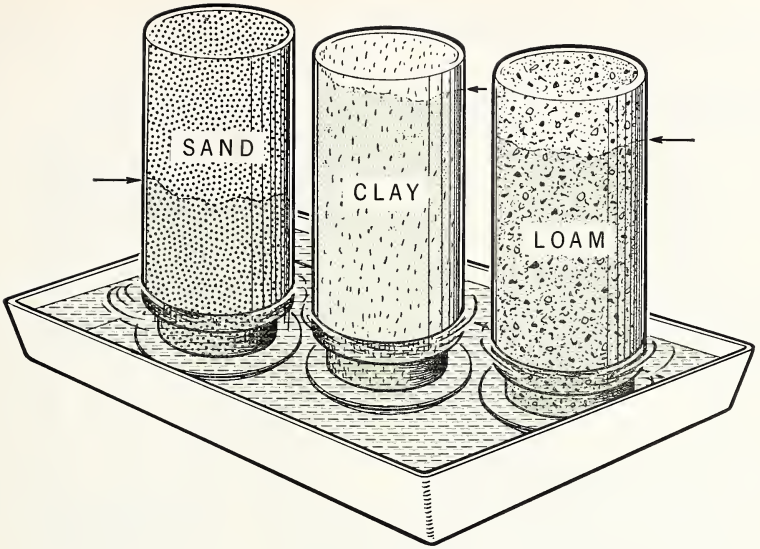
Ruth reported that barnyard manure is an important source of humus for soil in fields and gardens. Animals, too, form a part of the soil. When animals die, their bodies decay and add humus or organic matter to the soil.

Miss Peterson now asked the class, "What is the main problem that we have been studying in our science this week?" Several pupils volunteered the answer: *How Has Our Soil Been Formed?* The pupils then listed briefly the chief agents of soil formation: *water, glaciers, changing temperatures, wind, plants, and animals.*

"The combined efforts of all these forces over many millions of years have produced and are still producing the precious soil of the earth without which life, as we know it, would be impossible. This is the soil that feeds us," concluded Miss Peterson.

### Why is soil water important?

While plants can be grown without soil by suspending them with their roots in water rich in plant food, they cannot grow in even the richest soil without adequate supplies of water. There are two reasons why plants require adequate supplies of water: (1) Plants can use foods from the soil only if these are in solution in the soil water that they absorb through their tiny rootlets; (2) These plant-food materials dissolve very slowly in water, and so only a very small quantity of them is present in soil water at any one time. Therefore, very large quantities of water are required to supply the needs of growing plants. Accurate experiments have shown that about twenty tons of water are required in producing one bushel of wheat. Do you understand, now, why it is that bumper crops occur only in years when there has been plenty of rain?




Experiment to show the rise of water in soils. Water has just been poured into the pan. In which soil material will water rise the highest? Loam represents a soil rich in humus.

**How does water move to dry parts of the soil?**

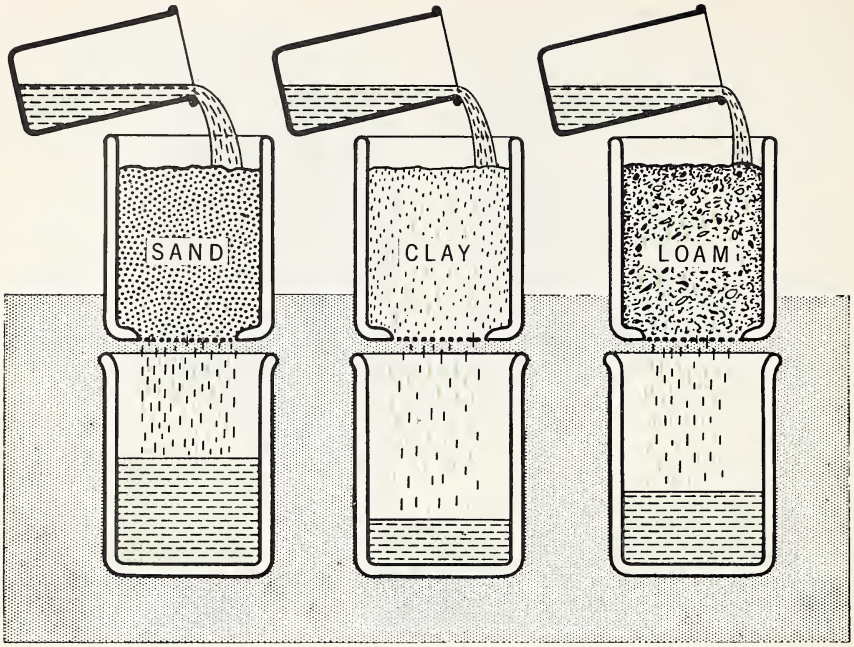
As oil rises in a lamp wick when one end is immersed, or ink spreads on a blotter, so also water tends to move through the soil. When one part of the soil becomes dry, as a result of the moisture having been absorbed by the roots of plants or having been evaporated, water moves from the moist soil over to the dry area. The force that causes the spreading of moisture is called *capillarity*. By performing the experiments that follow, you will learn more about this process.

SOMETHING TO DO

*Problem.* — Through what kind of soil does moisture move most readily?

*Apparatus and Material.* — Three tall glass jars (taller glass cylinders are better if available); three saucers; a shallow pan; water; samples of *dry* sand, clay, and loam soil. (For the loam, either secure some soil that is rich in leaf-mold, or mix pulverized, well-rotted barnyard manure with ordinary soil.)

*Method.* — Be sure that the soil is thoroughly dry. Pulverize each sample (use a hammer if necessary). Fill one jar with sand, another with clay, and the third with loam. Having covered the mouth of each with a saucer, invert in the shallow pan. Pour into the pan about an inch of water. Notice the *rate* at which the water rises in each jar. In which soil does the water rise the fastest and in which does it rise the highest?




Experiment to test the water-holding capacity of soils. If an equal amount of water is poured into each can, which of the three soil materials will allow the least water to run through? Which will allow the most?

*Observations.* — Record your findings regarding the speed at which the water rises in each soil material and the height it rose in each.

*Conclusion.* — State what you have learned about the movement of moisture in sandy, clay, and loam soils.

*Application.* — As a general rule, will moisture move more readily in finer or in coarser soils? In well or in poorly cultivated soils?

Your experiment should show that water rises fastest in sand and slowest in clay. If tall glass cylinders are used as containers for the different soil materials, it can be shown that water rises highest in the clay and lowest in the sand.

## Which kinds of soil hold water best?

Some soils remain moist much longer than others under similar conditions. Since all soils are composed of sand, clay, and humus, the amounts of these materials in the soil must have something to do with the ability of the soil to retain water.

### SOMETHING TO DO

*Problem.* — What is the effect of sand, clay, and humus on the water-holding ability of the soil?

*Apparatus and Material.* — Three equal-sized tin cans (such as 28 oz. size); three equal-sized catch-basins (tin cans, 20 oz. size); sand, clay, and humus (the humus is not satisfactory by itself — you should therefore pulverize well-rotted manure or leaf-mold, and mix it with ordinary soil). The three soil materials must be well pulverized and dry.

*Method.* — Punch five small holes near the centre of the bottom of each of the 28-oz. tin cans. (If in punching holes the bottom is bent in, press it out again). Pour sand into one of them until it is about two-thirds full. Measuring accurately, put an *equal amount* of clay into the second tin, and humus-soil mixture into the third. Now stand each of them on the top of a 20-oz. tin (see diagram on page 230). Measure out three equal quantities of water (three 20-oz. tin canfuls, for example). Pour one measureful of water through each material. Wait until all samples have ceased dripping, then with a ruler, measure the depth of the water in each catch-basin.

*Observation.* — What was the depth of the water in the container under each soil material? Since equal amounts of sand, clay, and the humus-soil mixture were used, and equal quantities of water were poured through each, *the amount of water that ran through into each catch-basin will help you find out the amount of water held back by each kind of soil.* Check this carefully.

*Conclusion.* — Which soil held back the most water? The least?

*Application.* — Would the presence of sand in soil increase or decrease the water-holding ability of the soil? How would the presence of clay affect it? The presence of humus?

Soils hold water on the surface of their particles. As you have already learned, a clay soil is composed of very fine particles and a sandy soil is made up of coarse particles. It has been proven that the total surface area of the particles in a certain volume of clay is much greater than the total surface area of an equal volume of sand. Hence clay can carry more water on the surface of its particles than can sand. This fact explains why clay soils have a greater water-holding capacity than do sandy soils.

It follows, then, that the presence of sand in soil decreases the capacity of the soil to retain moisture. Water readily drains down through sandy soils, which consequently tend to dry out very quickly. Clay in soil increases its water-holding power. Some clay soils retain too much water and are too slow in drying up in the spring. Humus has a good effect on the water-holding capacity of both sandy and clay soils. It acts as a sponge and, when present in quantity in sandy soils, helps to retain in the soil an adequate supply of water. Since clay soils are inclined to hold too much water, the effect of humus is beneficial. The humus opens up the soil so that surplus water drains away. You can readily see, therefore, why it is important to keep a supply of humus in the soil. Good ways to supply humus to the soil are by adding barnyard manure, compost, or dead leaves, or ploughing under leafy crops, such as clover and rye.

In Ontario, many clay farms hold so much water that it is necessary to drain off the surplus in open ditches, or through tiles laid in the soil.

### The farmer's greatest problem—moisture conservation

Every farm needs plenty of water. In dry areas the need for water is often very great. Probably no other problem is as important to the farmers of Western Canada as the conservation of moisture. In many parts of the Prairie Provinces, the average annual precipitation (rain and snow) is barely sufficient for the growing of crops. In years when it has been below the average, many crop failures have resulted from the lack of moisture. The greatest care must be taken to conserve in the soil as much as possible of the moisture that reaches it.

Summerfallowing is a common farm practice in Western Canada. By cultivating the fields for a season without cropping them, weeds are killed and moisture is stored. A trash cover is left to prevent wind and water erosion. (P.F.R.A. photo)

Many farmers not only are doing their utmost to prevent loss and waste of soil moisture, but also are building dams and excavating dugouts for storing water. The object is to catch the run-off from melting snow and heavy rains and hold it for use during periods of dry weather. At such times, the stored water can be used by the farmer to irrigate his garden, his hayland, and in some cases even a part of his grain fields. Such schemes are not practicable on all farms, but in Saskatchewan alone, hundreds of them are operating satisfactorily.

### Cheating the drought by summerfallowing

Moisture may be conserved also by summerfallowing a part of the farm every year. This land is left without a crop and, during the summer, is cultivated with various implements. Thus weeds are destroyed, and the soil is kept in a state that allows rain to soak readily into it. The minimum of cultivation necessary to control weeds is considered sufficient to conserve moisture. In this way the moisture of the summerfallow year is stored up, and the crop the following summer receives the advantage of two years' moisture.

Periodic summerfallowing is an essential farm practice in Western Canada, where the usual practice is to summerfallow one-third or even one-half of the cultivated acreage each

year. As the rougher surface and the partly exposed trash provide effective protection from drifting, it is essential in localities where soil-drifting is common, to use implements that will leave the stubble and other trash mixed into the surface soil rather than completely buried as it would be if the soil were ploughed. This is best done by using the disk harrow or the cultivator. Ploughs are now little used in many parts of the West.

**SOMETHING TO DO**

1. Find out from farmers in your district what methods they are employing to conserve moisture. Ask them to explain to you their reasons for adopting the methods they are using. Discuss with them the suggestions outlined in this chapter. Keep a record of your discussions, and report at school.

2. Watch newspapers and farm magazines for reports of investigations being carried on in connection with the conservation of soil moisture.

**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

1. Explain the importance of the soil in helping to feed, to clothe, and to shelter us.

2. Tell in your own words how our soil has been formed. Be sure to refer to the work of such agents of soil formation as water, wind, glaciers, temperature changes, plants, and animals.

3. Explain how the fineness of the soil particles influences the movement of soil water.

4. Outline an experiment to determine the kind of soil through which capillary moisture moves the fastest and the highest.

5. Make a diagram illustrating an experiment used to learn the effect of sand, clay, and humus upon the water-holding capacity of the soil.

6. What are the advantages of summerfallowing? What precautions need to be taken to make sure that summerfallowing does not lead to soil-drifting?

## WHAT MAKES A SOIL FERTILE?

Sometimes in spring when the crops are a few inches above ground, heavy rains occur, resulting in the flooding of low-lying areas in some fields. If the water stands on a field for several weeks, the plants become sick and die. People say that the crop has been "drowned out." Could it be that the crop has been smothered to death? Does soil contain air?

**SOMETHING TO DO**

Partly fill a glass tumbler with dry soil. Quickly add about an inch of water. What do you see escaping through the water?

The bubbles of gas that you observed rising through the water are bubbles of air. The water you poured over the soil moved down among the soil particles and forced out the air.

Air is very important in a fertile soil. It is essential for the germination of seeds and for the growth of roots. Air is necessary for the activities of the many kinds of useful bacteria that abound in the top few inches of the soil.

Growing plants require a constant supply of oxygen just as growing boys and girls do. They get this supply of oxygen from the air. If the source of air is cut off, as happens when a field is flooded, the plants soon smother to death.

### What constitutes good soil?

We have already learned some things about good soil. We have learned, for example, that a fertile soil requires a good supply of *air* and *moisture*. Why are they necessary?

Our experiments have shown that a good soil is not made up entirely of rock material. It also contains decayed plant and animal material, which as you have learned, is called humus or organic matter. Humus improves a soil in several ways. Being dark in color it absorbs sunlight and therefore helps to warm up the soil quickly in spring. It increases the water-holding capacity of a soil. It is a rich source of nitrogen for growing crops. It aids the activity of beneficial soil bacteria that help to maintain the fertility of the soil.

To be fertile, a soil must contain in readily available form an adequate supply of chemical elements that are essential for plant growth. Among these are *nitrogen, phosphorus, potassium,* and *calcium*. Plants can use these elements only in the form of soluble salts held in solution in soil water. In this form they can be taken into the roots by the process of osmosis. As these minerals are used up, they must be replaced by the addition of fertilizers containing them, in order to keep the soil fertile.

### Soil fertility should be conserved

The fertility of even the richest of soils is not inexhaustible. Crop after crop may be grown successfully with no apparent injury to the soil, but, in time, loss of fertility is certain unless definite steps are taken to replenish the necessary minerals. Is it good practice to allow plant food materials to be removed from the soil year after year without making any attempt to replace them? It may be possible to restore the lost fertility, but often the process is very costly.

A good farmer thinks not only of the immediate returns from his soil, but also of his returns for years to come. Indeed, he thinks of returns not only for himself but also for future generations. The future of Canadian agriculture depends more upon the soil than upon anything else. Prosperity in the years to come will be greatly influenced by the manner in which the broad, fertile agricultural lands of Canada are cultivated and

managed today. If the farmers' only concern is for the present and for large, immediate returns, future prosperity is by no means assured.

Plants remove from the soil certain materials that must be replenished. What are these materials, and how can the supply of them in the soil be maintained? You will find the answers to these questions in the following paragraphs.

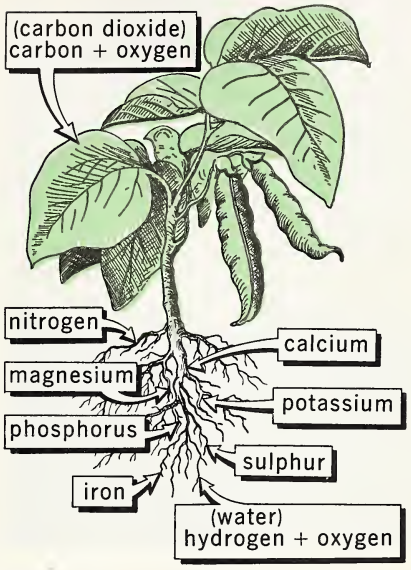
**What do plants require from the soil?**

It has been found that at least ten substances, or elements as they are called, are essential to the growth of plants. Plants do not grow well if even one of these elements is lacking. The following are the ten essential elements: *carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, calcium, iron, sulphur,* and *magnesium.*

Carbon, for the most part, is obtained from the carbon dioxide of the air through the leaves. Hydrogen and oxygen are secured from the soil water that is absorbed by the roots. For the other seven essential elements the plant is dependent on the materials of which the soil is composed.

*Nitrogen* increases the *deep green color* of plants, and is necessary for *growth* and for *protein manufacture.* It is used in large quantities by all plants, especially those, such as wheat and clover, that produce large amounts of protein, and those that make very rapid growth.

*Phosphorus* encourages *root development.* It hastens *ripening* and is necessary for the *formation of seeds.*

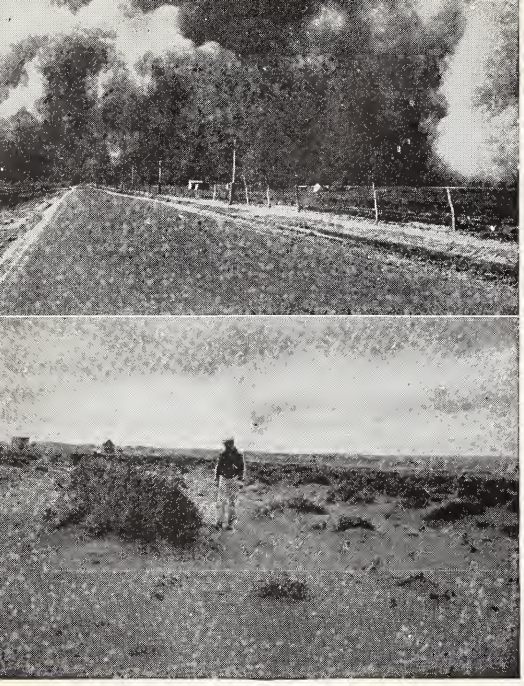



Ten elements are essential for plant growth. Which elements are taken in through the roots and which through the leaves? Traces of certain other elements also are necessary for the healthy growth of plants. Name several of them.

The other five elements also have special work to perform in the life processes of the plant. In addition, *boron, copper, manganese,* and *zinc* are required for healthy growth of plants. These are known as *trace elements* because only very small amounts are used.

**Plant food materials in the soil must be soluble**

As you have already learned, food materials are taken into plants in solution form. For this reason they must dissolve in water; otherwise they are of no value to plants.



Top: A dust storm in progress. Bottom: The result of wind erosion; the richest layer of the soil is blown away. (P.F.R.A. photo)

Insoluble substances in the soil are changed into soluble materials by the work of useful *bacteria.* When you pick up a handful of good surface soil, it does not appear to contain much life, but in reality it is teeming with millions of bacteria.

The bacteria family of plants is a very large one. It includes disease-producing bacteria, the soil bacteria that we are discussing, and many others. Some bacteria are harmful; others are useful in various ways. Those that change insoluble substances in the soil into soluble plant food materials are in the useful class. Without their assistance, crops could not be grown.

The beneficial soil bacteria, like other plants, require food, moisture, warmth, and air. Keeping the soil well enriched with materials such as manure, supplies the necessary food. Moisture, warmth, and air are provided by proper cultivation.

### The loss of soil fertility

A fertile soil is one that is capable of producing good crops. Fertility depends largely upon the supply of plant food materials in the soil; but also it depends to some extent on the ability of the soil to hold moisture, and on the cultivation it receives.

Every crop grown on a piece of land leaves the soil poorer by the amount of the essential elements used. Millions of tons of these elements are taken from the soil each year when crops are harvested. *Weeds, soil-drifting, excessive cultivation,* and the *wearing away of the soil by running water and wind,* all reduce soil fertility. Unless methods are adopted to conserve, and, when necessary, to restore the supply of materials required by the plants, the soil gradually will become useless for growing crops.

Usually there is sufficient of most of the essential elements in our soils to supply plants with their requirements. The elements that may be lacking will depend on the locality. For example, in parts of Alberta, only two, nitrogen and phosphorus, are commonly present in insufficient quantity, while in Ontario, a third element, potassium, may also become scarce.

Five ways in which fertility is lost from soil. Which of these five losses can be prevented by a farmer? How?

These, therefore, become an important factor in crop production. For example, there may be enough sulphur and enough calcium and magnesium to produce fifty bushels of wheat per acre, but if there is sufficient nitrogen or phosphorus for only a twenty-bushel crop, then the yield will be only twenty bushels.

The conservation of soil fertility is of first importance in building up a system of prosperous, permanent agriculture. Some of the methods used by farmers and gardeners to maintain the fertility of their soil are the growing of *legumes,* the practice of *crop rotation,* the raising of *livestock,* and the use of *barnyard manure* and *chemical fertilizers.*

Farmers also can do much to maintain the fertility of their soil by using recommended methods of stopping erosion of the soil by wind and water.

All of these methods of conserving soil fertility will be discussed at greater length later in this chapter.

**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

1. Name the seven essential elements that plants secure from the soil.
2. What necessary elements are not obtained from the soil? Where are these elements obtained?
3. Before they are useful to plants, the essential elements in the soil must be in soluble form. Explain the reason.

4. How are the plant food materials that are found in the soil changed to soluble forms?

5. Ontario farmers often buy fertilizers to spread on their fields. Name three elements that the farmers would expect to replenish by this method. Which two of these elements sometimes need to be replenished on prairie farms?

## RESTORING SOIL FERTILITY

Plant foods can be returned to the soil by growing plants that produce and restore plant food, by ploughing in barnyard manure, and by applying commercial fertilizers.

### How legumes restore nitrogen

There is an abundance of nitrogen in the air, but most plants cannot use it in this form. They must secure it from *nitrates* in the soil. However, one family of plants, the *legumes,* can use the nitrogen of the air in an interesting way. They have on their roots, irregular-shaped, small, white lumps or *nodules.* The nodules are the homes of certain bacteria that are able to change the nitrogen of the air in the soil into nitrates, which the legumes use for food. In this peculiar and unusual situation, the bacteria, as it were, receive board and lodging from the legumes, and pay their rent and board bill by supplying the legumes with large quantities of nitrogen in the form of nitrates. The nitrogen thus secured is stored in the roots, stems, and leaves of the legumes. When the legume dies and decays, the nitrogen in its body is left in the soil, from which it can be secured by other plants, such as wheat, oats, potatoes, carrots, and trees, that cannot use the free nitrogen of the air as legumes do. Some common legumes are *peas, beans, soybeans, clover, alfalfa, caragana,* and *vetches.*

The practice of growing legumes after nitrogen-using crops is a widely employed method of conserving soil fertility. Legumes also add humus to the soil.

#### SOMETHING TO DO

1. Make a list of the legume crops that are being grown to enrich the soil in your district. To make sure that you have the correct information, consult several farmers.

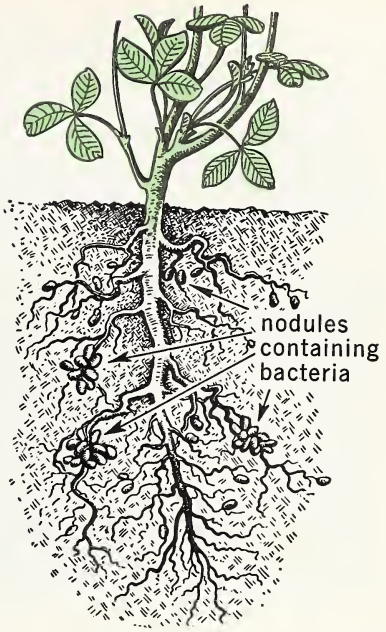
2. Carefully dig up a bean, pea, alfalfa, or clover plant, and examine the roots for nodules. They are usually readily found in the roots of garden peas and beans in the early fall or on clover roots in any growing season.

### Crop rotations

It has been found that if the same grain crop is grown for many years on the same piece of land, the crop eventually does not grow so well. Weeds, plant diseases, and insect

Ploughing under a crop of sweet clover to add nitrogen and humus to the soil. (Ontario Department of Planning and Development photo)

pests may become a serious problem. The soil may lose much of its fibre and become subject to soil-drifting. Certain plant food elements may be reduced to the point where crop yields are poor. However, if a farmer grows several kinds of crops in succession on the same land over a period of years, many of these difficulties do not arise, or, if they do, they can be kept under control. In some parts of Canada, a farmer may grow a grain crop in a field this year, a grass or clover crop next, pasture cattle in the field in the third year, and the fourth year grow a cultivated crop, such as potatoes, sugar beets, or corn. The following year he would start over again with a grain crop which would be followed in turn by hay crop, pasture crop, and cultivated crop. Such an arrangement would be




The root system of a legume. Explain (1) how the bacteria help the legume, and (2) how the legume helps the bacteria.

a four-year *crop rotation*: (1) grain, (2) hay, (3) pasture, (4) cultivated crop. Similarly, a prairie farmer might use a three-year rotation such as: (1) wheat, (2) oats, (3) summerfallow. In the fourth year, following the summerfallow, the field would again be sown to wheat.

#### SOMETHING TO DO

Find out what crop rotations are being used by the farmers in your district. In what ways are they considered to be good rotations?

A good system of rotating crops results in a more balanced removal

1959

| | | |
|---|---|---|
| Wheat | Hay | Pasture |
| Summer-Fallow | Oats | Wheat |

1960

| | | |
|---|---|---|
| Hay | Pasture | Wheat |
| Wheat | Summer-Fallow | Oats |

A six-year crop rotation showing the location of the different crops for two successive years. Draw another plan to show the arrangement for 1961. How many years will elapse before each crop will occupy the same field as in 1959?

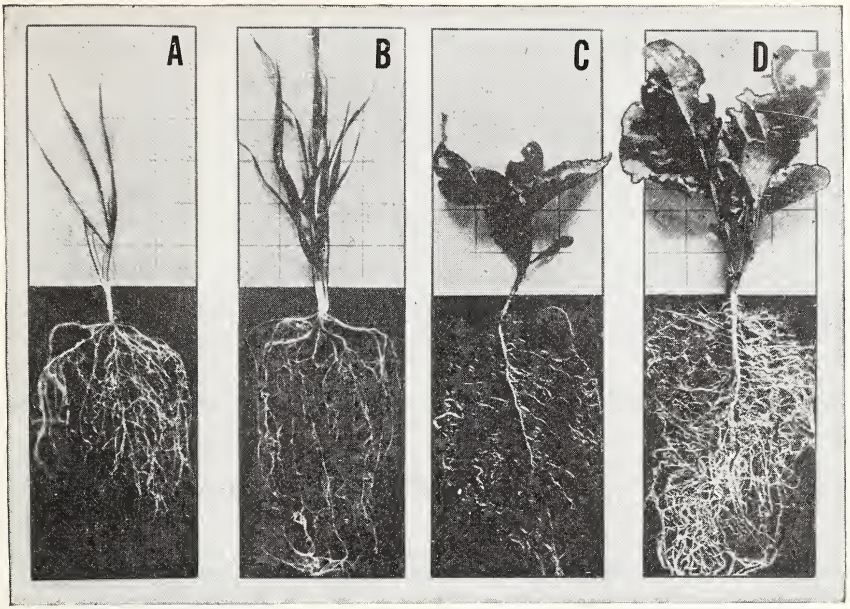
of plant food materials from the soil. If legumes such as sweet clover or alfalfa, and grasses are included in the rotation, they enrich the soil by adding humus to it. They help to maintain fertility by stopping soil erosion by wind and water. In addition, as we have already learned, legumes restore nitrogen. Cultivated crops make it possible to get rid of weeds that rob the soil of its plant foods. An insect pest or a plant disease that thrives on one crop may not attack a different type of crop; therefore, by a well-planned cropping system, these plant enemies may be kept in check.

### Livestock and soil fertility

When crops are sold directly as grain or hay, the plant-food elements taken from the soil also are sold and are thus a total loss to the land. But if certain crops are fed to livestock and marketed indirectly as milk, meat, or wool, a part of the elements removed is returned to the soil in the form of manure, which contains valuable supplies of nitrogen, phosphorus, and potassium. Because of its strawy nature, manure also adds humus to the soil. It thus encourages the activity of beneficial bacteria (see page 236) and improves the water-holding capacity of the soil.

Livestock encourage the conservation of soil fertility also by providing a use for the legume or grass crops that a farmer may desire to grow in his rotation. Indeed, as we discovered earlier, livestock are essential to a permanent system of agriculture.

In what ways are livestock important in the maintenance of soil fertility? (Saskatchewan Government photo)




These photographs illustrate the increase in root and leaf development that resulted from the application of fertilizer to the soil. The soil in which plants A and C grew was not fertilized. Fertilizer was applied to the soil in which plants B and D grew.

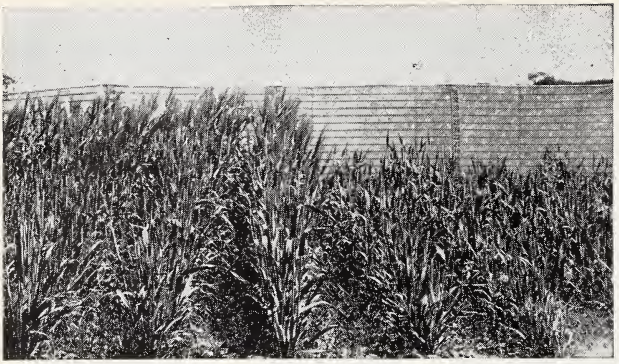
### Hurrying plants with chemical fertilizers

To replenish the supply of essential plant-food elements, many gardeners and farmers add to their soil certain substances called *chemical fertilizers.* The use of fertilizers encourages the rapid growth of potatoes, onions, lettuce, celery, flowering plants, etc. Lawns also may be improved by the application of fertilizer.

Profitable returns are now being obtained from the use of fertilizers on most field crops, such as wheat, mangels, and turnips. Greater root development, more rapid growth, hardier plants, and increased yields result. Carefully conducted experiments have shown that by the proper use of chemical fertilizers the yield per acre of root crops such as turnips and mangels can be increased by as much as 300 per cent. These increases in yield are sufficient not only to cover the cost of the fertilizer but also to leave a sizeable extra profit for the farmer.

#### SOMETHING TO DO

1. Find out if the gardeners and farmers in your locality are using chemical fertilizers on their gardens and fields.



Chemical fertilizers increase the yield of barley. The plants on the left were grown in soil to which fertilizer had been applied, those on the right in unfertilized soil. (Department of Agriculture photo)

If so, discuss with them the methods of applying the fertilizers and the results they have obtained. Report your findings to your class.

2. Obtain from a local store, samples of the different chemical fertilizers being offered for sale. Put each sample into a small glass jar with a screw top. Label each jar with the name of the fertilizer. Keep this set of jars for a permanent collection.

3. Read the instructions that come with lawn or garden fertilizers to learn what precautions need to be taken when applying these chemicals to a lawn or garden.

4. Plan and carry out experiments with fertilizers.

(*a*) Select two similar groups of house plants. Treat one group with plant food tablets, being sure to follow directions. Do not give the second group any food tablets.

Keep both lots of plants at the same temperature. Water them at the same time and with equal quantities of water.

Observe the growth of both groups of plants from week to week. Do the fertilized plants show more vigorous growth and produce larger blooms? Why was it necessary to keep all but one condition the same for all plants?

(*b*) Apply a chemical fertilizer that is rich in nitrogen to one-half of your lawn. Leave the other half unfertilized. Water both halves of the lawn with equal amounts of water.

After two or three weeks, note any difference in growth and color of the fertilized and unfertilized parts of the lawn.

What is your conclusion?

(*c*) Plan and carry out a similar experiment to find the effect of fertilizers on garden or field crops.

NOTE. — In applying fertilizers to any crop, it is most important to follow the instructions of the manufacturer. *Some fertilizers burn the plants if they are applied in the wrong way.*

Do not become impatient with your fertilizer experiments. Keep in mind that scientists do not always see their results in a day or two.

The chemical fertilizers that are commonly sold on the market contain good amounts of all of the elements that are most likely to be in short supply in the soil. These elements, as you

have already learned, are nitrogen, phosphorus, and potassium. They are present in the form of soluble salts. Fertilizers available on the market differ somewhat in the proportions of nitrogen, phosphorus, and potassium they contain. It will depend on the nature of the soil and the requirements of the crop to be grown, which fertilizer will suit the situation the best. For grain crops such as wheat, a mixture in which there is an abundance of phosphorus is usually recommended. For potatoes and sugar beets, a fertilizer rich in potassium is the best. The requirements of clay soils differ from those of sandy soils; this should be taken into consideration when selecting fertilizers.

Gardeners and farmers who try to follow the scientific method in growing crops, will find out first of all what essential elements are deficient in their soils, and what elements are required in large amounts by the crops they intend to grow. With these facts before them they will select the fertilizer that best meets these needs.

**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

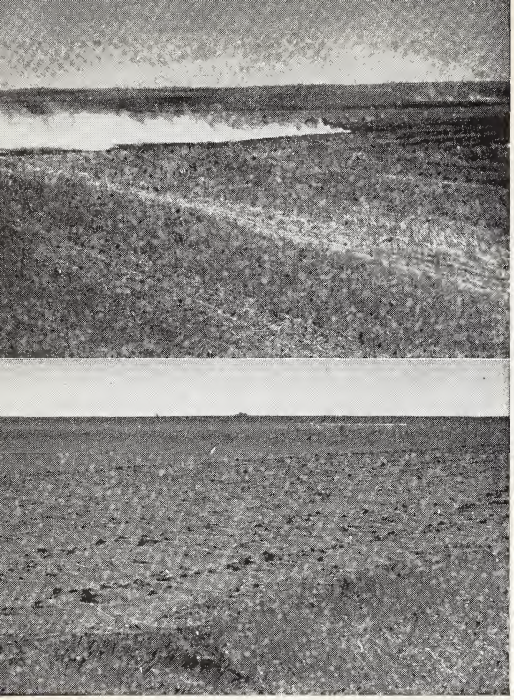
1. Of what value are legumes in maintaining soil fertility?
2. What is the source of nitrogen for most plants?
3. Discuss the importance of livestock in conserving the fertility of the soil, showing how livestock tend to make farming more permanent.
4. Mention four ways in which plants may be improved by the use of chemical fertilizers.

## HOLDING THE SOIL IN PLACE

When settlers first came to Canada, the soil of the country was protected by a strong, durable covering of grass and trees. The roots held the soil in place, and neither rains nor winds could wash or blow it away. Now, however, farming and lumbering operations have removed much of this protective covering. Wind and running water loosen the topsoil particles and carry tons and tons and tons of it from our fields, turning rich farming land into poor soil. As you know, the wearing away of soil by wind and water is known as *erosion.* In many places where the land has been cropped for a long time, there are areas in which the fields have been so badly eroded that profitable crops can no longer be grown on them.

### Soil-drifting

In the prairie regions of Canada and the United States, soil-drifting has seriously damaged, and in many cases totally destroyed, the crops on thousands of acres of farmland. Soil-drifting produces the following disastrous results: (1) The topsoil, the most productive layer, is frequently



Top: Stubble being burned off a prairie farm. Bottom: The same field on the very next day. Note how the soil has been drifting. (Regina Experimental Station photos)

blown away. (2) Tender young crops are cut down by drifting particles of soil. (3) Weed seeds are carried from field to field and from farm to farm. (4) Roadways are blocked, ditches are filled, and fences and wind-breaks of trees are piled high with the drifting soil. (See page 236.)

### What causes soil-drifting?

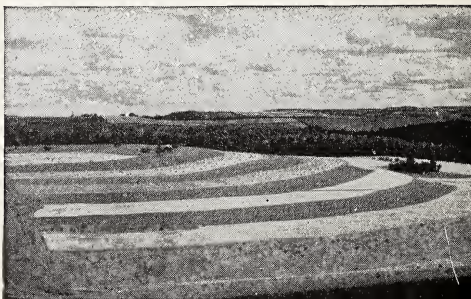
Though the wind is to a great extent responsible for soil-drifting, it is not the only cause. Soil-drifting is largely the result of the condition of the soil. The particles of a soil that is well supplied with fibre, or that has not been too finely pulverized by excessive cultivation, will hold together, and the soil will not drift even when there is considerable wind. *Bad farming practices,* that leave the soil in poor condition, are largely responsible for soil-drifting.

### What is the remedy for soil-drifting?

Land covered by a crop will not blow. But a crop cover cannot be kept on the soil continuously. The fields lack a crop cover once a year, during cultivation. On the prairies, during years when a field is in summerfallow, a cover crop is lacking for a longer period. The problem of preventing soil-drifting, then, resolves itself into two parts: (1) how to keep the soil covered as continuously as possible, and (2) how to cultivate it when it is not protected by a covering crop. There are several ways of solving the problem.

1. *By strip farming.* The crop is sown in strips alternately with strips of summerfallow. The strips are about fifteen rods wide, and are sown across the direction of the prevailing

Strip farming is widely used in some localities to control wind erosion. The light colored strips are strips of crop. The dark colored areas are strips of summerfallow. (Soil Conservation Service photo)



wind. How does this keep the soil from drifting? (See illustration at bottom of page 244).

2. *By summerfallowing without ploughing.* Some implements, such as the cultivator, leave much more stubble and other material mixed with the surface soil than does the plough. This "trash cover" holds the soil particles together and prevents drifting.

3. *By keeping the soil in good condition.* This may be done by growing grass and legume crops to restore fibre, by refraining from burning stubble that holds the soil in place, and by keeping more livestock to enrich the soil with manure.

4. *By sowing a light "cover crop" of oats* on the summerfallow in the late summer, to produce sufficient growth to check drifting the following spring.

5. *By sowing a crop of rye* in the fall and harvesting it the following summer after danger of drifting is past.

6. *By planting trees and caragana hedges* to afford the soil protection from the full force of the wind.

How do farmers in your district combat soil-drifting?

### Soil erosion by water

The whirling clouds of soil drifting before a strong wind are so plainly seen and so spectacular that it is easy to realize that quantities of soil are being blown away. But water erosion, it is claimed, "may steal the soil from underneath one's feet without one's noticing it." Soil experts state that there has been a noticeable increase in the erosion of our soil by water during recent years.

Water erosion occurs most frequently on sloping lands, and on pasture lands where the grass has been eaten too short by too many livestock pasturing on it. It creates problems for the farmer because it washes away much of the rich topsoil from his land and digs gullies that make cultivation, especially with heavy modern machinery, very difficult.

Erosion of soil by water can be divided into three stages: *sheet erosion, rill erosion,* and *gully erosion.* Study the example of sheet and gully erosion shown below, and of rill erosion on page 257.

#### What conditions cause soil erosion by water?

Erosion by water is one of the most sinister enemies of our soil. If we take the trouble to examine the destructive results of water erosion and to

Water erosion destroys soil fertility. Starting with sheet and rill erosion (background), soon deep gullies are formed as shown in the foreground of this photograph. (Ontario Department of Planning and Development photo)

consider the conditions under which erosion occurs, we shall fully realize the need of employing methods for preventing soil erosion.

#### SOMETHING TO DO

1. Perhaps your class can organize a field trip for the purpose of learning, first-hand, about soil erosion. Often it is possible to see the results of soil erosion without leaving the school yard. Or you may decide to visit a farm where serious erosion has taken place.

Look for examples of the three kinds of water erosion illustrated on pages 245 and 257.

2. Measure the depth of a gully in a field in spring. Mark the spot well. Make another measurement a few months later and calculate how much erosion has taken place during one summer.

NOTE. — One group of pupils who carried out this experiment found that the gully they had measured in a field was one and one-half feet deeper in the fall than it was in the spring.

Several factors affect the amount of erosion by water on Canadian farms: (1) the amount of rain, (2) the slope of the land, (3) the type of soil, (4) the methods of farming.

1. Have you ever watched the soil in your school yard being carried away by streams of water during a heavy rain? If so, you will realize that heavy rains cause more erosion than gentle showers. Most areas in Canada usually have at least one heavy rain a year, and much damage may result if the land is not in condition to resist the cutting effect of the surface run-off of water.

2. As you know, water runs off sloping surfaces much more readily than off level land, and the steeper the slope the faster the water runs. Long slopes, even though they are gradual, are more dangerous than short ones, because water gains speed as it runs downhill. The faster it moves, the more soil it carries with it. Indeed, when the speed of water doubles, its ability to carry soil particles is increased sixty-four times!

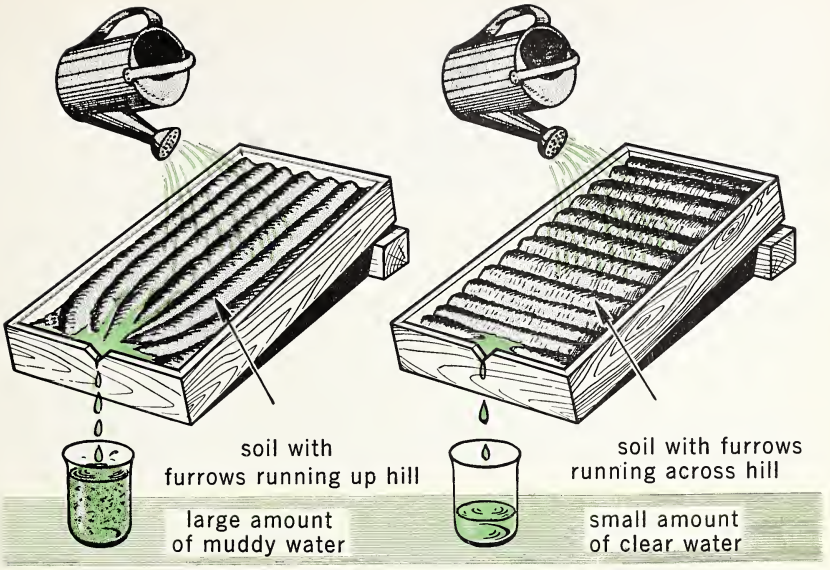
3. Finer soils suffer more from water erosion than coarse soils. Water that falls on sticky clay soils and on soils that are lacking in humus does not soak into the ground, but runs off over the surface, carrying much of the soil with it. Soil that has been pulverized by wind erosion is easily washed away.

4. In many cases, farming practices make it easy for water to carry away soil. Cultivating sloping surfaces up and down the slope leaves channels in which the rain water runs away rapidly and carries soil with it.

### How can water erosion be controlled?

We have learned that water erosion is a serious problem. On the first signs of damage by erosion in a field or garden, steps should be taken to stop it.

In Ontario, and many other areas, erosion by water is a much more serious problem than is wind erosion. As has already been stated, water erodes soil more on slopes than on level ground. How can this water erosion of soil be prevented?




Soil erosion experiment. Obtain two equal-sized shallow boxes and cut a notch in one end of each. Put an equal amount of soil into each box. Tilt as shown. Make furrows up and down the slope in one box and across the slope in the other. Arrange beakers to catch the run-off. Using a sprinkling can, gently pour equal volumes of water onto the soil in each box. Note the volume and color of the water that collects in each beaker. What does this experiment prove?

**SOMETHING TO DO**

*Problem.* — How does the way in which a field is ploughed affect soil erosion?

Perform an experiment to discover if water erosion in a field can be greatly lessened by ploughing the field across the slope instead of up and down it.

A suitable experiment is illustrated in the drawing above. Set up this experiment and follow the directions.

What observations do you make?

If possible, you should repeat the experiment using a different kind of soil. Are the results about the same as before?

What are your conclusions?

These experiments show that the amount of soil erosion by running water is affected by the way in which the soil is ploughed. The erosion is much greater when the furrows run up and down the slope than when they run across the slope. Therefore, sloping land should be *cultivated across the slope* and not up and down it. The furrows of the plough or cultivator will form dams to hold back the water after heavy rains until it soaks into the soil, instead of allowing it to run down the slope carrying valuable soil with it. Cultivation across a slope,

This field has been cultivated across the slope. Water from a heavy rainfall is lying in the furrows where it has collected, instead of rushing over the field and washing away the soil. Compare what is happening in this field with the soil erosion taking place in the illustration on page 245. (Soil Conservation Service photo)

or around a hill, is known as *contour cultivation* (see illustration below).

**SOMETHING TO DO**

*Problem.* — Can water erosion of a field be controlled by means of a grass crop? Perform the experiment illustrated on page 250. What are your observations? Now answer the question asked in the problem. Write up the experiment in your science note-book, using the usual headings: *Problem, Apparatus, Method, Observations, Conclusion.*

*Strip cropping*, as illustrated at the bottom of page 244, with the strips running across the slope, also checks the force of running water. *Using manure, growing soil-improvement crops* such as grasses and legumes where practicable, and *seeding down gullies to grass* are other valuable means of preventing and controlling water erosion.

**Food for thought**

History teaches us that, in the past, the decline and fall of great nations and even of empires has often been closely linked with the loss of soil fertility by erosion. Long ago in northern China, the mountainsides were stripped of their forest covering. This permitted the forces of wind and water to carry away the fertile topsoil, thereby leaving the land barren and useless for growing crops.

Palestine had a similar experience. A few thousand years ago, the forested hills provided a steady flow of water the year round. There was plenty of water to irrigate the crops to produce a sufficient supply of food for three million people. Then a fatal mistake was made. In order to have more land for farming, the hillsides were cleared of their forests. As a result, with no trees and spongy forest cover to hold in check the spring run-off, water rushed rapidly down the slopes and filled the rivers to overflowing. Flooding and serious soil erosion of the open fields and plains resulted. Later in summer, the

Study this illustration carefully. It shows an area of country in which contour cultivation is being practised to prevent soil erosion. Explain. (J. I. Case Co., photo)

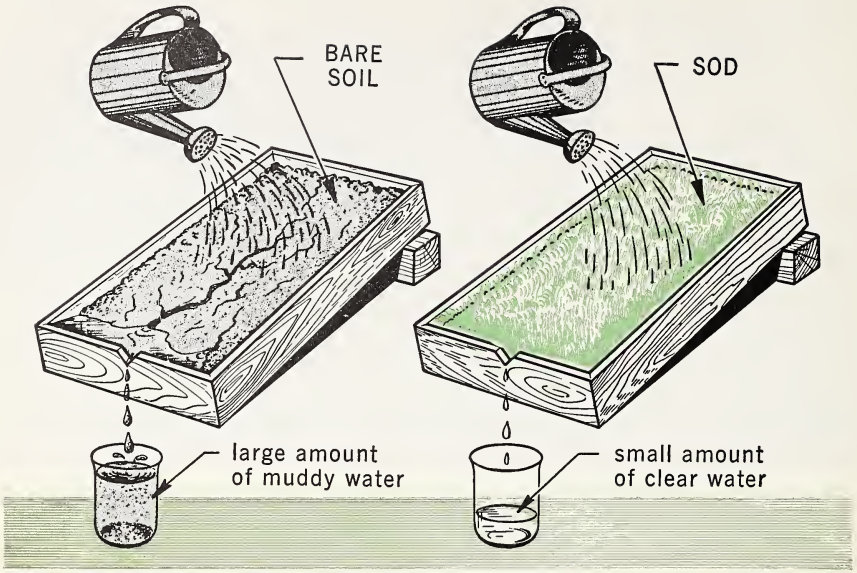
The dark strip shows a natural runway for water across the fields of this farm. The runway has been seeded to grass so that in spring when the snow is melting, or after heavy rains in summer, the grass will prevent the erosion of the soil by running water.

streams were reduced to a trickle. There was not enough water to irrigate the crops. The treeless hills were unprotected from wind and water erosion. The richest part of the soil, the topsoil, was gradually carried away, thereby impoverishing the land to such an extent that it could support a population of only 200,000 persons.

Some north African countries suffered the same fate, and for similar reasons. Fertile lands, that at one time had produced abundant food supplies for the great Roman Empire, were reduced to desert wastes as a result of poor farming practices and the destruction of the forests.

Thus we see that failure to conserve their most important natural resource, the soil, caused the downfall of more than one great country. Some of these countries originally had soil just as rich as Canada has today. Let us remember this and think about it. There is need for us

The soil provides us with food, clothing, and shelter. However, unless we take proper care of it, in time it will become barren and useless. (J. I. Case Co., photo)




Set up the apparatus as shown. Sprinkle equal amounts of water on the soil in each box. In which case was there a greater run-off of water? In which case was the soil erosion the greater? Why should a grass cover be kept on hilly land?

to be on our guard and to take suitable action to make certain that such a calamity does not happen in our country.

Many persons in authority are deeply concerned about the loss of so much valuable soil through wind and water erosion, and are urging immediate action. They are trying to make people generally realize the extent of the damage and the need to put an end to it at once.

**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

1. How does each of the following help to prevent erosion of the soil by water: (1) forests on hillsides, (2) grass crops, (3) contour cultivation, (4) strip cropping with strips running across the slope, (5) grassed waterways? Which of these would help also to stop wind erosion?

2. (*a*) Is soil-drifting responsible for serious losses in your locality? Make a list of the various ways in which it is harmful.

(*b*) Outline methods for remedying soil-drifting in your district. Arrange your suggestions in order of importance. Which methods do you consider might have the most permanent effect?

3. In what ways may cultivated fields or pastures be seriously damaged by water erosion? In your answer include the names of the three kinds of water erosion.

4. Make a list of the causes of water erosion of soil, and opposite each cause briefly outline possible ways to overcome it.

5. Why does a sudden heavy rain cause more damage by erosion than a steady rain? Assume that the same amount of water falls in both cases.

## SOIL CONSERVATION AND DEVELOPMENT PROGRAMS

To solve the many problems related to soil and water conservation, a number of government-sponsored community organizations have been established in recent years. Good examples of such conservation agencies are the Prairie Farm Rehabilitation Act, commonly referred to as the P.F.R.A., in Western Canada, and the River Valley Authorities in Ontario. Both of these excellent organizations have made remarkable progress in solving pressing problems related to water and soil conservation, thereby preventing serious losses and possible disasters. There is an old saying that "an ounce of prevention is worth a pound of cure." Nowhere does this apply more aptly than in matters of conservation.

### What conservation work has been accomplished by the P.F.R.A.?

The P.F.R.A. was organized to carry out a program of work aimed at greater security and stability for prairie agriculture. Many projects have already been completed by the P.F.R.A., and others will be undertaken from year to year. These projects all centre around the *control of soil-drifting*, the *better utilization of land*, and the *conservation of water* for farm purposes.

At first, the P.F.R.A. directed its efforts toward the restoration of farmlands that had been laid waste by drought and soil-drifting. It helped the farmers in the affected areas to solve their problems by co-operative action and to re-establish their farms on a liveable and profitable basis.

More recently, the P.F.R.A. has stressed prevention rather than cure.

A dugout in a community pasture in Western Canada. Notice that a fence keeps the cattle away from the dugout. The windmill pumps water from the dugout into the watering trough where the cattle are drinking. (P.F.R.A. photo)

Examining a field of crested wheat grass. Because of its resistance to drought and its value as a pasture crop, this excellent grass and other new grasses are being used extensively in the Prairie Farm Rehabilitation Act regrassing projects. (P.F.R.A. photo)

A concerted effort is being made to remove the causes of the conditions that formerly had made restoration programs necessary.

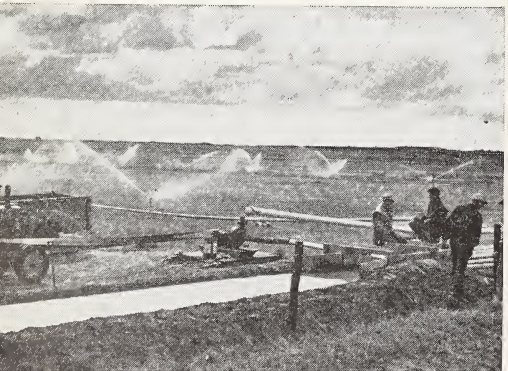
In some districts, large areas of land that have proven to be unsuitable for grain growing are withdrawn from cultivation and set aside for use as *community pastures.* These pastures are fenced and provided with stock-watering facilities. Land that is bare is *resown to grass.* This improves the land for grazing and also prevents erosion by wind and water. In these areas the raising of livestock is encouraged. Local farmers graze their cattle in the community pastures at a fixed charge per animal. Each pasture is managed on a co-operative basis by a committee of farmers in the community. Altogether about two million acres of land are involved in this project.

Throughout the prairie region, the P.F.R.A. provides both *engineering* and *financial assistance* to individual farmers and to groups of farmers for the construction of *water storage works* such as *dugouts* and *dams.*

A dugout is an excavation in a low-lying part of the ground for catching and storing water. A satisfactory size is 65 x 165 feet, with a depth of 12 to 15 feet. This is large enough to store about 400,000 gallons of water, which is sufficient to meet the needs of the average farm for three years. Dugouts are located where they will catch the water run-off from melting snows in spring and sudden heavy rains in summer. They supply water for household use, for livestock in winter as well as summer, and for irrigating gardens. More than 50,000 such dugouts have been constructed on the Canadian prairies where vast areas cannot depend on wells for their water.

Rivers, coulees, and ravines that receive a large spring run-off usually afford good sites for *dams* that will hold back large amounts of water. Many small stock-watering dams have been built by individual farmers with the help of free engineering service and the financial aid of the

Irrigating by the sprinkler method. Note the ditch in the foreground in which water flows from an irrigation dam to the fields. A tractor (left) supplies the power to operate the pumps that force water from the ditch through aluminum pipes to the rotating sprinklers. (P.F.R.A. photo)



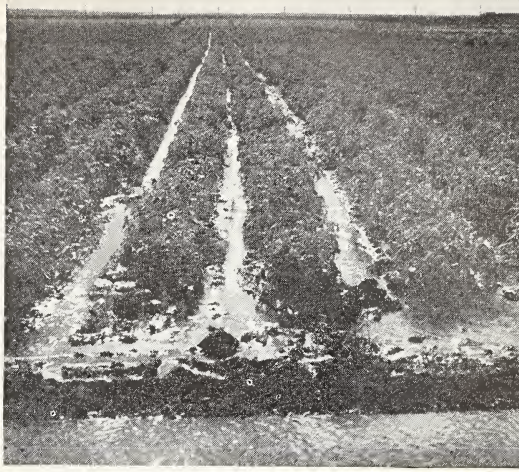
P.F.R.A. Larger dams, however, are constructed as community projects. The P.F.R.A. assists towns and other community centres to erect dams in order to have a sufficient supply of water available for schools, hospitals, and shopping areas, as well as for homes and fire protection. The communities make application for them, supply the property required, and agree to operate and maintain them on a co-operative basis. The P.F.R.A. gives free engineering services and shares construction costs with the community.

Larger water conservation projects of this kind, especially when well treed, in many cases have become *recreation centres*. People for miles around often gather along the shores of these artificial lakes on holidays or weekends for picnics, swimming, boating, or fishing. Such healthful recreation facilities help to make the prairie population more permanent.

Now that most rural areas in Western Canada are supplied with electric power, many farmers have modernized their homes with electric lights and running water. Often the water for this purpose is pumped from a nearby dugout. Farm homes with city comforts and conveniences help to make farming more enjoyable.

A number of *irrigation projects* on a large scale have been developed by the P.F.R.A. Water is stored behind large dams, from which extend canals and ditches to carry it to the fields.

Wherever possible, the P.F.R.A. uses the services of existing organizations, such as experimental farms, to solve drought and other farm problems. Finances are provided by the P.F.R.A. to carry out the necessary investigations. The results of these investigations are passed on to all who wish advice on how to make the best use of their land.



Irrigating a crop of potatoes by the ditch method. Note the ditch in the immediate foreground, in which water from a nearby irrigation dam is flowing. From this main ditch, water is led off in lateral ditches among the rows of potato plants. (P.F.R.A. photo)

In these and other ways the P.F.R.A. has helped to conserve our soil and water resources for the benefit of the prairie people. Possibly this is one of the greatest co-operative conservation projects ever undertaken, involving as it does, the conservation of people as well as of soil and water.

#### SOMETHING TO DO

1. Obtain information about P.F.R.A. and other conservation projects in your locality. How were they financed? Why were they established?

2. Find out about the Agricultural Rehabilitation and Development Act (A.R.D.A.). This Act permits the federal government to enter into cost-sharing agreements with a province for agricultural projects, such as, research, alternate uses of low-producing land, soil and water conservation, and increasing income and employment opportunities in low-income areas.

3. Prepare a report about one of the River Valley Authorities in Ontario. See pages 291 and 293 regarding the Don Valley Conservation Project.

### TEST YOUR KNOWLEDGE AND UNDERSTANDING

1. Outline the purposes of the P.F.R.A., showing how it should improve farming conditions in the areas affected.

2. Discuss the statement: Native grasslands are one of our greatest natural resources and should be carefully conserved.

3. The Canadian government helps to finance P.F.R.A. activities. What is the individual farmer's responsibility? Show that P.F.R.A. undertakings are co-operative.

4. Show how the scientific method of solving problems has been followed by those who carry out the work of the P.F.R.A.

5. Every known form of water development has been utilized by the P.F.R.A. Mention some of them.

## WHAT HAVE YOU LEARNED?

### IMPORTANT SCIENCE IDEAS AND UNDERSTANDINGS

A

1. Soil helps to provide us with almost all of our food, and much of our clothing and shelter.

2. Soil is formed from broken-down rock material and decayed plant and animal matter.

3. Many forces of nature are constantly at work wearing down rocks into soil particles.

4. A fertile soil contains air, moisture, and helpful bacteria in addition to a readily available supply of minerals.

5. The conservation of soil fertility is essential to a permanent system of agriculture.

6. There are a number of ways in which a good farmer or gardener can help to maintain the fertility of his soil.

7. Forests on hills and mountainsides help greatly in the prevention of soil erosion by water.

8. Soil-drifting can be checked by following the suggestions offered by authorities in soil conservation.

9. Scientific agriculturists have discovered a number of ways of controlling water erosion of soil.

10. The P.F.R.A. assists the prairie farmers in the conservation of their land and water resources.

(a) The foregoing sentences are all true statements of important science ideas and understandings. Read and discuss them carefully as a review of this chapter.

(b) The following sentences describe situations in which some of these ideas apply. To test your ability to apply ideas to actual situations, match the sentences in A with sentences in B to which they apply.

B

1. During a class discussion on conservation of soil and water, Sharon Kearns quoted a Chinese proverb that says: "To rule the mountain is to rule the river."

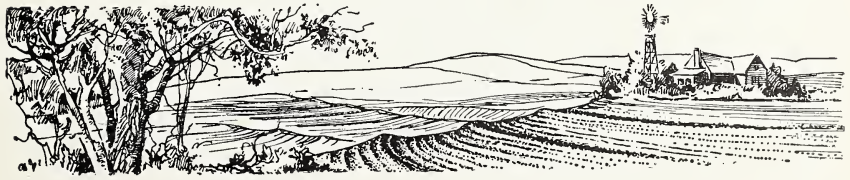
2. In Western Canada where nature is lavish with sunshine but sparing with moisture, the struggle for a good living is to a large extent a struggle for water.

3. For many centuries the Incas of Peru terraced their hillside fields across the slope.

4. Ben Olson reported to his class as follows: "It has been proven by experience that sloping cultivated fields lose soil by water erosion about 400 times as fast as similar fields on which a grass crop is well established."

5. Mr. Brown followed the policy of cropping his land year after year without making any provision for restoring some of the elements that were in short supply. His idea was to make as much money as possible over a period of a few years, then sell his farm and retire to a warmer climate.

6. A neighbor of Mr. Brown's had an entirely different approach to farming. He used a good cropping system including legumes. He fertilized his fields with barnyard manure and also with chemical fertilizers. He followed the advice of scientific agriculturists in the control of soil erosion by wind and water.



7. On her way home from school, Edith Brown noticed that some of the rocks along the road were quite rough and crumbly on the surface, some had big cracks in them, and others were almost covered with lichens.

## IMPORTANT SCIENCE TERMS

### A

| | | |
|---|---|---|
| soil | conservation | cover crop |
| humus | elements | summerfallow |
| glacier | bacteria | contour cultivation |
| glacial drift | crop rotation | strip cropping |
| weathering | chemical fertilizer | P.F.R.A. |
| erosion | legume | community pasture |
| capillary moisture | nodule | dugout |
| soil fertility | soil-drifting | River Valley Authorities |

To show that you understand and can use the science terms in A, match with the situations described in B those terms which apply.

### B

1. Mrs. Smith brought home some leaf mold from the woods to mix with the soil she was preparing for her window-box.
2. After a heavy rain, Marie Lucas noticed that little ditches had been formed in the garden by running water.
3. Using engineering advice and financial assistance from the P.F.R.A., Mr. Shaw made a dugout to store water from the spring run-off.
4. Wheat crops feed heavily on nitrogen and phosphorus.
5. Mr. Smith did not believe in growing the same crop on a field year after year. He used a system whereby he grew a number of different crops over a period of years and then started all over again.
6. Sweet clover belongs to a group of plants that are able to take the free nitrogen out of the air in the soil and store it in their roots in the form of soluble nitrates.
7. As soon as he had finished summerfallowing his field, Mr. Jones seeded it lightly with oats.
8. In 1935, the federal government of Canada set up an organization to help the farmers of Western Canada solve their drought and soil problems.

9. Cover crops, strip cropping, and ploughless summerfallowing have all been used at one time or another to solve one of the prairie farmers' most urgent problems.

10. Ronald Shaw reported to his class as follows: "Fields on hillsides that are ploughed across the slope are not nearly so likely to have their fertility carried away by water erosion as are fields on hillsides that are ploughed up and down the slope."

11. Whether we own land or not, we are dependent upon the products of the soil for the necessities of life. Each of us has a vital concern in the use, management, and improvement of our soil resources to maintain or increase productivity.

**SCIENTIFIC METHOD AND ATTITUDES**

1. The farm of Mr. Kendal was badly run down. It no longer produced paying crops. For years Mr. Kendal had followed the farming methods used by his father and his grandfather before him. He paid no attention to what he termed "new-fangled ideas of agricultural experts." His attitude was that a "dirt farmer" knows better than the experts how land should be farmed. He took no steps to control soil erosion or to replenish the fertility of the soil with chemical fertilizers or in other ways. He continued to cultivate his fields in the same way year after year and to grow the same crops on them as had been grown there for many generations. He blindly refused to change his methods to conform with the results of scientific investigations.

Rill erosion. Notice the rills (small gullies) formed when water ran downhill between corn rows. The soil deposited at the bottom of the hill has covered crops and fertile soil.

What scientific attitudes did Mr. Kendal fail to show? Review the attitudes of a scientist as described on pages 12 to 15, then answer the question.

2. One summer, Walter Forbes' father noticed that his lawn had lost its rich green color. It was now yellowish green. He knew that nitrogen is necessary to give leaves a dark green color; so without further investigation or consideration of other possibilities he decided that the trouble with his lawn was lack of nitrogen. Mr. Forbes remembered reading in the daily newspaper about a new chemical fertilizer that is very rich in nitrogen. He decided to buy some and experiment with it on his lawn. He spread the fertilizer over all his lawn by the handful, without reading and following the directions on the container. In a few days the grass was badly burnt and yellower than before. Mr. Forbes concluded that a nitrogen fertilizer has no value in keeping a lawn a deep green color.

What steps of the scientific method did Mr. Forbes follow? What steps did he overlook? Was his conclusion justified? Why? Review the six steps of the scientific method outlined on pages 28 to 30 before answering the foregoing questions.

United States Forest Service

*Till taught by pain,*
*Men really know not what good water's worth.*
*—Lord Byron "Don Juan"*

# CHAPTER 8

CHAPTER 8

# WATER, THE VITAL LIQUID

Water is our most useful and abundant liquid. How different our earth would be if there were no water! What are the important uses of water? What is the water cycle? What makes water hard? Most sources of water contain many undesirable materials. How is water purified in cities, on farms, and at summer cottages? How can we conserve this precious liquid?

At the beginning of the science period one day, Miss Peterson said, "During the past few months, we have been studying man's basic needs and the ways in which science helps us provide for these needs. We have learned how science helps us to grow better food-producing plants and to store fresh foods for later use, how we can help to conserve the soil that is so vital in producing the foods we need, and how modern science has improved our clothing. Another of man's very important requirements is a dependable supply of fresh, clean, safe water. Water is sometimes called 'nature's greatest gift'; it is our most essential liquid, and fortunately it is also our most abundant one. Let us think of places where water exists."

Edward Wentworth was able to offer a suggestion immediately.

"You can find water almost everywhere," he said. "In rivers, streams, lakes, ponds, swamps, and marshes you can find plenty of water."

Roy Kendal enlarged the list. "We should include the oceans," he began. "I learned from a science book that there is more ocean water than any other material at the surface of the earth. It also said that if all the land on earth were levelled off, water would cover the land to a depth of two miles! At one place the ocean is over six miles deep! You can see on our globe that about three-quarters of the earth's surface is water."

"There's water in the ground, too," Jean Graham continued. "Last fall when we studied roots we learned that plants take in water through their roots. On farms, drinking water comes from wells in the ground."

"Near our house there's a spring where water pours out of the soil on the side of a hill," added Ruth Osmak.

"There is water in plants and in animals," Gordon Wayne remarked.

"We've all seen ice and snow," said Roger Forbes. "We know that they are really water in its solid form."

"Then we should count the water vapor in the air, too," Edith Brown added. "We know that water *evaporates* and becomes a gas called *water vapor*."

Howard Kovacs summed up the discussion. "When we think of water as a liquid, as a solid, and as a gas, we know that there is some water almost everywhere. Even in the desert there must be some water, or cactus plants wouldn't be able to live."

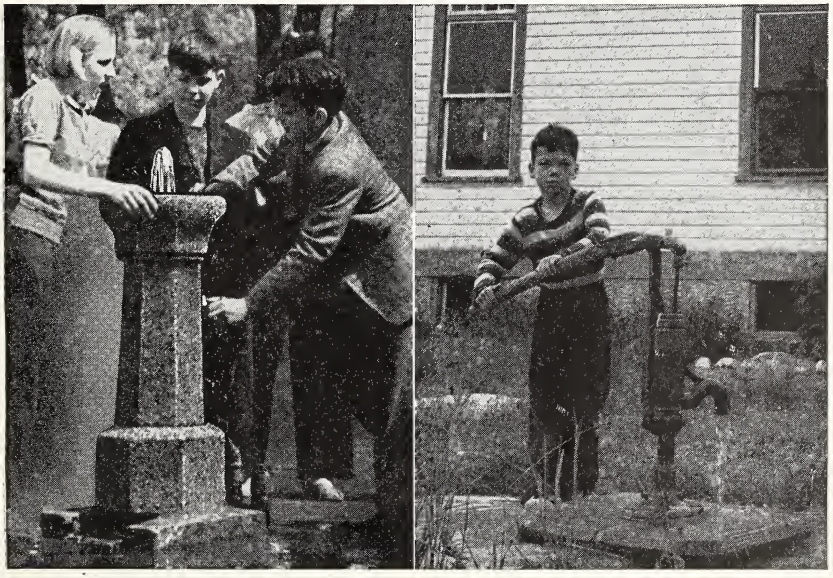
## WATER HAS MANY IMPORTANT USES

After discussing the sources and forms of water, the class decided to find out the major uses of water.

The class was organized into a number of small committees, each of which selected one important use of water for discussion. The following day, several reports were given.

### Domestic uses of water

The first group contended that the most important use of water is for



Whether we get our supply from tap, fountain, or pump, we all require plenty of safe, clean water for healthful living. (National Film Board photos)

Top: A dependable water supply could change the desert area in this photograph into useful farming land. What evidence can you find to show that there is at least some water in this area? By irrigating with water from rivers and lakes, much barren land on our continent has been made productive. Bottom: Adequate rainfall and fertile soil have helped to produce these fine orchards and gardens. (Top photo, United States Fish and Wildlife Service; bottom, J. I. Case Co. photo)

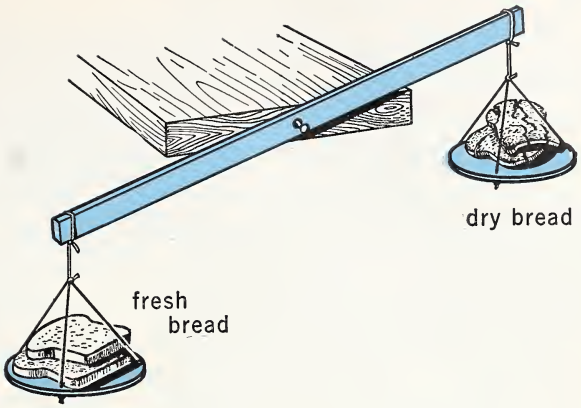
domestic purposes. If you had no food, you could probably live for several weeks, but without water, or some food containing very large quantities of water, you could live for only a few days.

Early tribes of people realized the importance of a supply of clean water for drinking and bathing, and for washing dishes, food, and clothing. Today, providing an adequate supply of safe water is one of the greatest responsibilities of city and town governments. On the farm, too, a supply of clean, safe water is essential.

You may be surprised to learn that water in your body is responsible for about two-thirds of your weight. Your blood contains a large amount. Your flesh and even your bones, in fact all the living cells of which your body is composed, contain water.

Water helps us digest our food and carry it in the blood to all parts of the body. The wastes produced in the cells are carried away by the blood and removed by the kidneys. You will recall that in summer you are kept cool by the evaporation of the water in the drops of perspiration which escape through the pores in your skin. Water in the air you breathe keeps your lungs and nostrils from becoming dry and sore. Tiny drops of water permit your eyeballs to move about freely in their sockets.

You should replace the water your body loses, by drinking five or six glasses of water each day, and by eating foods which contain large amounts of water.




Using a simple yardstick-scale or balance to find out if there is water in food. Place equal weights of a food on each pan. Put the lot from one pan in a closed container to keep it from drying out; thoroughly dry the other lot in an oven. Again place both lots on the pans. Account for the fact that the pans do not balance.

Most of the foods we eat contain some water. Some of them, such as milk, fruit juice, and raw and cooked vegetables, all of which are important in our diet, contain large amounts of water. The diagram on page 264 will provide you with information about the amount of water in four common foods.

You can investigate for yourself the amount of water in various foods by weighing them, then drying them out in an oven, and then reweighing them.

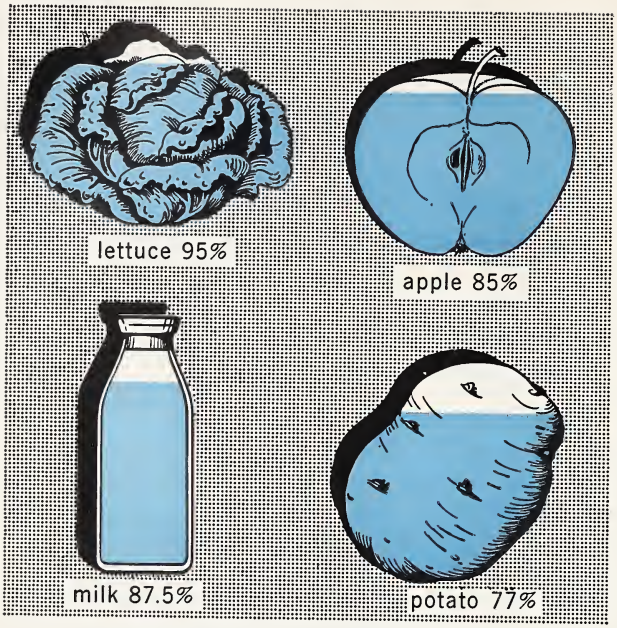
There are other important domestic uses of water. Firemen depend on an adequate supply of it in fighting fires. We use large quantities of water to carry away sewage. Most furnaces have pans from which water is evaporated into the heated air, making it moist and healthful.

For many of us, water is so easily obtained from tap or pump that we do not stop to consider how important it is in our lives and how badly off we should be without it. Think of getting along for even a day with no water at home or at school for washing and drinking purposes!

Man has always been greatly dependent upon water for drinking purposes and as a means of travel and transportation. More recently, as you will learn, he has become increasingly dependent upon large quantities of water for an even greater number and variety of uses. The problem of finding an adequate water supply is becoming a very difficult one for the people of many areas.

### Farming depends on water

As you have seen what happens to your garden or lawn during a long dry spell, you already know that plants require large amounts of water. You will recall that plants can use minerals from the soil only when the minerals are dissolved in water. Water forms the greater part of the sap which carries food to the leaves




The percentage of water, by weight, in four common foods. What are the two ways by which we can keep our bodies supplied with the large amounts of water that they require?

and flowers. Water forms a part of every plant cell, and is one of the raw materials used in making starch. Plants use vast quantities of this vital liquid. It takes five hundred pounds of water to grow *one pound* of dry hay!

Farm animals, also, use large amounts of water. Dairy cattle require plenty of clean water so that they can produce large quantities of milk. Beef cattle also need water for meat production. For the production of *one pound of beef* over 30,000 pounds of water are needed! This quantity includes the water that the animal drinks and the amount used by the crops that it eats in producing one pound of beef.

In dry areas, *irrigation* is necessary for the growth of good crops. In some parts of the prairies, crops are irrigated by means of canals and ditches which carry water from nearby rivers. In many parts of Southern Ontario, early market vegetables are irrigated by large overhead sprinklers supplied with water pumped from lakes and streams. If enough irrigation water were available, millions of acres of dry soil on our continent could become rich farmlands (see page 252).

#### SOMETHING TO DO

By performing the following tests you will be able to observe the way in which water is able to dissolve many materials.

1. Stir a teaspoonful of sugar in a glass of water. Taste the *solution* of sugar and water. Where has the sugar gone?

2. Find out if salt dissolves in water. The oceans are composed of a solution of water, salt, and many other minerals.

3. Find out by experimentation which of these substances can be dissolved readily in water: chalk, baking soda, sand, a stone, soap flakes, and a solid detergent.

4. Shake up a teaspoonful of fertilizer in a glass of water. Does it all dissolve? Fertilizer contains minerals needed by plants. When fertilizer is mixed into the soil, these minerals dissolve slowly in the soil water and provide food for plants.

5. Will more sugar dissolve in hot water than in cold water? Carefully plan and perform an experiment to solve this problem. Repeat your experiment using salt and baking soda.

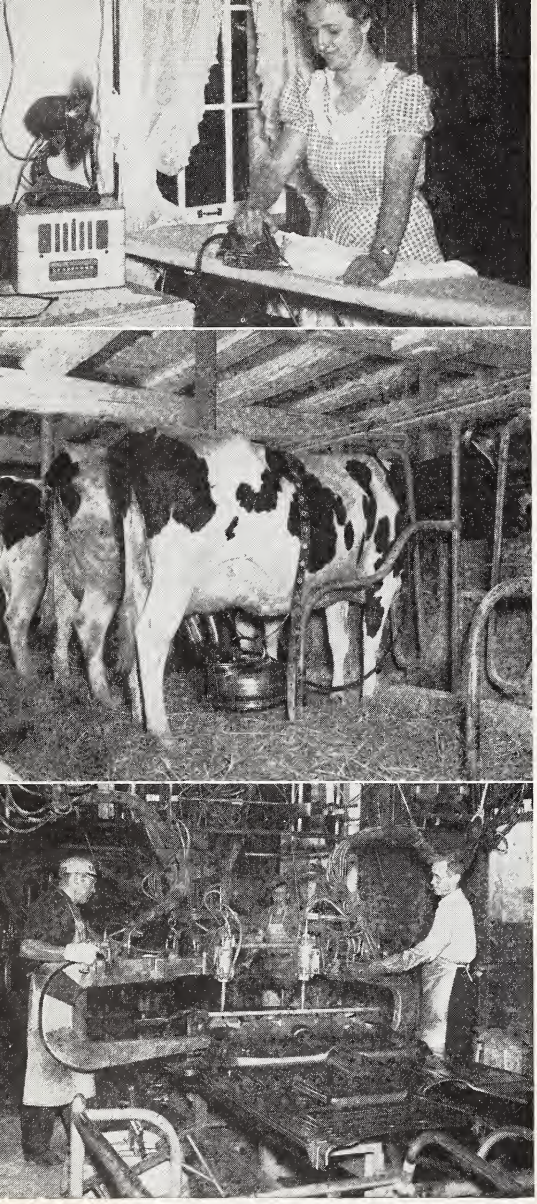
Scientists have learned that more substances will dissolve in water than in any other liquid. Why is the ability of water to dissolve minerals important for plant growth?

Livestock and wildlife need plenty of clean water. Top: Cattle drinking at a pond formed by a small dam in Alberta. Bottom: A bull moose, startled by the cameraman, hurriedly leaves the small northern Ontario lake where he had been eating water plants. (Top, Department of Agriculture photo; bottom, Ontario Department of Travel and Publicity photo)

**Industrial uses of water**

Great volumes of water are required by industries: to supply power, to process natural resources, to serve as a raw material, to keep buildings and machines cool, and to carry away wastes. Water power has been used for many centuries to turn the wheels of industry. Today much water power is changed to hydro-electricity which works for us in our factories and homes. Steam engines require large amounts of water. Steam power is commonly changed to electrical power which travels along wires to perform its work in many places.

The processing of our natural resources requires great quantities of water. A steel plant uses 400 pounds of water in the production of a pound of steel. Twenty-five gallons of water



The force in swiftly running water is harnessed to generate hydro-electricity which supplies light and heat and performs useful work in our homes, on farms, and in factories. What uses of electricity can you find in the top two pictures? (Ontario Hydro photos)

are used in removing one gallon of gasoline from petroleum. Paper cannot be made without the use of great volumes of water.

### Water for navigation

The lakes and rivers of our land are our least expensive "highways." The cost of shipping wheat from the Prairie Provinces through the Great Lakes is less expensive than shipping it by train. The logs from inland forests are shipped to pulp and paper mills merely by floating them down rivers.

In northern Canada, the rivers and lakes are the most common routes for travel. In winter, water in the form of snow and ice makes travel by snowmobile and dog-sled possible. The lakes of the north also serve as landing fields for airplanes.

The rivers and lakes of our country contributed to the exploration of the interior. Without these water "highways," the explorers would not have penetrated the frontiers so quickly.

### Water for fishing and recreation

Many Canadians whose homes are located along our lakes and oceans earn their living by catching the fish which thrive in such large bodies of water.

Water provides us with many types of recreation. Game fish supply us and our tourist guests with exciting sport and delicious food. Boating, sailing, and swimming are favorite

Loading pulpwood at Dryden, Ontario. Show that water eases the transporting of the pulpwood from the forest to this point, and from this point to the pulp mill. (Ontario Hydro photo)

Niagara Falls, a great natural water spectacle and outstanding tourist attraction, provides power which is used to produce hydro-electricity. (Ontario Department of Travel and Publicity photo)

water sports in summer; in winter, water in its solid form makes possible skating, skiing, and sleigh-riding.

Other types of recreation also depend on water. A lake or river adds beauty and peacefulness to a cottage setting. The wonder of a wild flower, the splendor of a waterfall, and the thrill of finding a wild duck's nest, or of seeing a deer or moose at the water's edge at daybreak, would not be possible without large natural supplies of water.

**SOMETHING TO DO**

1. Discuss why it is less expensive to ship wheat by boat than by train and truck.
2. Visit a local dairy and one other factory to find what uses are made of water.
3. Make a poster or bulletin-board display of pictures showing uses of water in farming, manufacturing, transportation, and recreation.
4. Discuss the importance of water to the tourist industry of the province in which you live.

**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

1. Give three reasons for calling water "the vital liquid."
2. What are the three forms of water?
3. State three uses of water in your body.
4. What domestic purposes are served by water?
5. Describe an experiment you would use in finding out if a kind of food, such as potatoes or bread, contains water.
6. In what three ways do plants use water?
7. Water dissolves many minerals. Why is this important to plants?
8. Briefly tell four ways in which modern industries depend on water.

Water is associated with many types of recreation, both in summer and in winter. What sports, other than the ones shown here, require water in one of its three forms? (Left, Ontario Department of Travel and Publicity photo; right, National Film Board photo)

## THE WATER CYCLE

When Lillian Barker went to feed the goldfish in her aquarium, which she kept covered with a sheet of glass, she saw several large drops of water on the underside of the cover. Did this water come from the water in the aquarium? Why did it form drops inside the cover?

### SOMETHING TO DO

Fill a dry glass with cold water. If possible, add some ice cubes or snow to the water. After a minute, examine the outside of the glass. What do you see? Remove some of this moisture. Taste it. Where did this water come from?

You will recall that water *evaporates* and becomes water vapor in the air, and that when water vapor is cooled it *condenses,* or changes back to liquid water. The cold glass cooled the air around it, causing some of the water vapor in the air to condense on the glass.

In Lillian's aquarium, some of the water changed to water vapor. As it touched the cool glass cover, the water vapor condensed, forming the large drops of water that Lillian saw. By watching the drops of condensation for a longer time, Lillian could have seen some of them fall, like rain, back into the aquarium.

The process that Lillian observed in her aquarium is very similar to the *water cycle* which brings us rain and snow. From every ocean, lake, river, lump of moist soil, and blade of

green grass, water vapor continually escapes and is carried high into the air. There, on cooling, it condenses to form clouds of tiny droplets of water. Further cooling changes the droplets to rain or snow, which fall to the earth and replenish the supplies of water that have evaporated.

### Changing salt water to drinking water

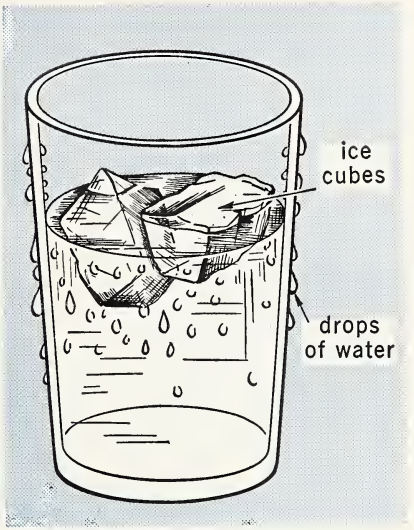
Oliver Sereda was reading the interesting story of a group of shipwrecked sailors who were adrift for several weeks in a small lifeboat on the Pacific Ocean. He learned that their greatest problem was obtaining enough water to drink. Oliver knew that salt water is not fit to drink, and wondered how the men could have changed it to drinking water. He asked his classmates how salt water could be changed to drinking water.

"That shouldn't be hard," Roger Forbes volunteered. "If you want to get dirt out of milk, you strain it out with a fine cloth. I think you could strain the salt out of water, too." Several pupils disagreed with Roger, so they decided to solve their differences of opinion by experimentation.

#### SOMETHING TO DO

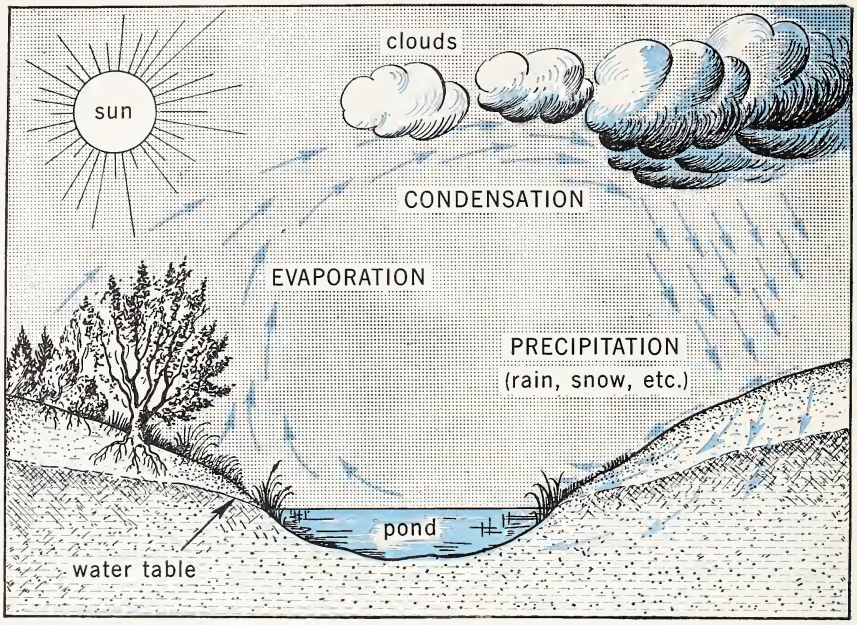
1. Make a solution of salt and water. Strain the solution through a very fine cloth or a filter paper. Is any salt left on the cloth? Does the water still taste salty? Can you filter or strain salt out of salt water?

Marie Lucas presented another possible answer to the problem. "I think if you let the water stand for a little while, the salt will settle to the bottom," she explained. "I've seen sugar in the bottom of a teacup, and dirt that has settled to the bottom of the water in the washing machine." Oliver thought that if the salt would settle, like dirt, out of the water, the surface water in the ocean should be free of salt. However, he watched with interest as some of the pupils performed an experiment to test Marie's idea.




Account for the drops of water (condensation) on the outside of the glass.

2. Dissolve a teaspoonful of salt in a glass of water. Taste the salt water. Let the water stand for ten minutes and then remove a spoonful of water without stirring up the water in the glass. Does the water still taste salty? Let the glass stand for an hour, two hours, and




The water cycle. Follow the travels of a drop of water from the time it evaporates from the pond, soil, or plants, until it returns to the pond.

a day, tasting it after each period of time. Is it still salty? Can you see salt at the bottom of the glass? Can you remove the salt from water by settling?

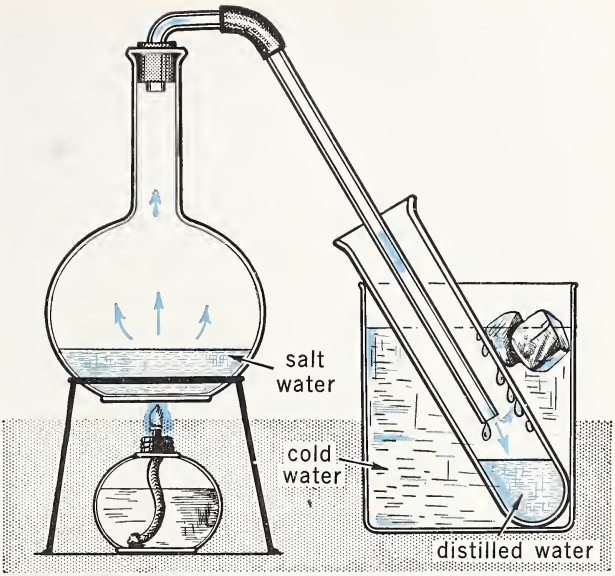
Helen Smith recalled what she had learned about the water cycle.

"Much of the rain that falls here must have evaporated from the ocean," she said. "But we all know that rain doesn't taste salty. I think that to get drinking water out of salt water you would have to evaporate some of the water and then cause it to condense again."

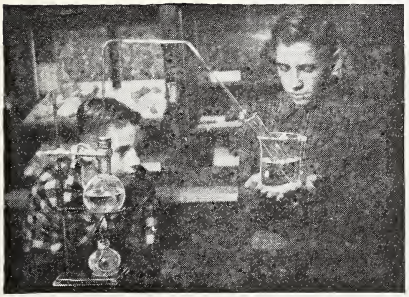
3. Prepare the equipment shown on page 271. Slowly heat the salt water in the flask. What appears in the test tube? Taste this water. Is it salty? We call water that has been produced in this way *distilled water.*

Oliver Sereda concluded that if the shipwrecked sailors in his story had had some method of evaporating the ocean water and condensing the water vapor, they would have had suitable drinking water. Equipment for producing distilled water from ocean water is useful in large ships.

In what ways is the production of distilled water similar to the water cycle? What speeds up the rate of evaporation? What cools the water




Right and below: Producing distilled water. Why does the steam condense in the test tube? Compare the distillation of water with the water cycle. (D. Nicoloff photo)



vapor in each case? What is produced?

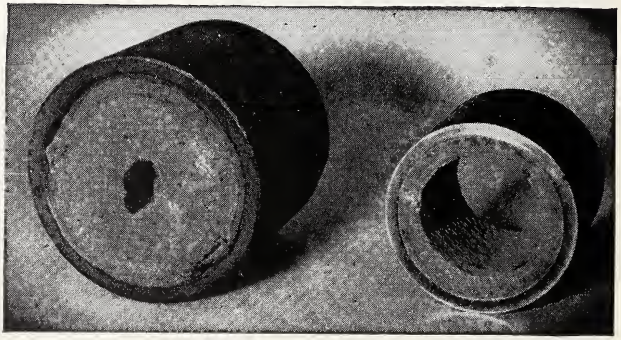
You now realize that rain is very similar to distilled water. Neither one has minerals dissolved in it, but each usually contains some specks of dust from the air.

### Hard and soft water

One summer day, Joan Wilson pumped some water from the well, heated it on the stove, and prepared to wash her hair. Although she used plenty of soap, few suds formed in the water, but a film of grey scum appeared on the surface. Joan was dismayed to find that her hair was also coated with this soap scum. Although she rinsed her hair several times, she could not wash away all the scum, and her hair appeared dull and stringy when it dried.

Joan's problem was caused by the use of the wrong kind of water. When rain falls to earth, it contains no dissolved minerals. We call such water *soft water.* When snow melts, it becomes soft water. The water in many lakes and rivers is soft. As water soaks into the soil, it dissolves many minerals. By digging a well into the ground, we obtain this *hard water.*

This girl washed the left side of her hair with hard water, and the right side with soft water. The same amount of soap was used on each side. Describe the difference in the appearance of the two sides. Insets: Through the microscope we see a dull film on the hair washed in hard water, while the hair washed in soft water is free of this film. (Permutit Company photo)



Deposits of minerals from hard water in a steam pipe and a hot-water pipe. Look for hard-water scale in your tea-kettle. (Aqua-soft Service Ltd. photo)

*Limestone* is the most common mineral in hard water, but often many other minerals are also present.

**SOMETHING TO DO**

Examine the scales inside a tea-kettle. Test them for limestone by putting a few

drops of vinegar on them. The bubbles indicate that limestone is present.

As the hard water in your teakettle boils, the water changes to steam and escapes, leaving the minerals it contained. In cities where the water is very hard, a thick coating of limestone forms in hot-water pipes. In some areas the dissolved minerals give hard water an unpleasant taste. However, hard water containing very small amounts of minerals is usually pleasant to drink.

### Why is soft water used for washing?

From Joan Wilson's experience in washing her hair, we learned that soft water is preferable to hard water for washing. By performing the following tests we shall find out why this is so.

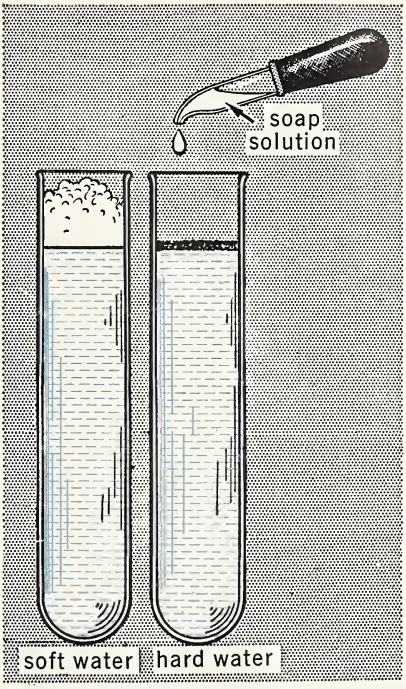
#### SOMETHING TO DO

Fill one large clean jar with water from a well (hard water) and another one with rain water (soft water). Label each. Rub a few drops of water from each jar between your hands. Do the drops from each feel the same?

Let us find out why soft water is used for washing.

Make a soap solution by putting a handful of soap flakes or one-quarter of a bar of soap into a small bottle of warm soft water; mix them thoroughly.

Pour soft water into a test tube or small jar until it is almost full. Pour an *equal* amount of water into another similar container. Label both test tubes. Using an eye-dropper, add, drop by drop, an equal number of drops of soap solution to each test tube, shaking them after each drop has been added. In which water did suds form first? How many drops were needed to make suds in the soft water? How many more drops were needed to form suds in the hard water? Did any scum form on the hard water?




Does soft water or hard water require less soap to form suds?

Repeat the experiment using salty water instead of water from a well. Does salt make water hard?

To form suds, soft water requires much less soap than hard water does. Before the soap can make suds in hard water, it reacts with the minerals to form a grey curd, part of which floats on the water. This is the kind

of dull scum that covered Joan's hair when she washed it in the hard water from the well.

### Making hard water soft

Unless it has an unpleasant taste, moderately hard water is usually satisfactory for drinking and for cooking, but as you have found out from reading about Joan Wilson's unhappy experience in washing her hair in hard water and from your experiments in testing hard and soft water for their ability to make suds, hard water is very unsatisfactory for washing. If no soft water is available, it may be necessary to soften the hard water with the use of chemicals such as *washing soda* and *borax.*

#### SOMETHING TO DO

*Problem.* — How does washing soda affect hard water?

*Materials.* — Two bottles; a jar of hard water from a well; a teaspoon; some washing soda; an eye-dropper; soap solution.

*Method.* — Pour a cupful of hard water into each of two bottles. Dissolve half a teaspoonful of washing soda in the water in one bottle. Label this bottle. Add some of the soap solution from your previous experiment, drop by drop, to each bottle, shaking the bottle after each drop.

*Observation.* — In which bottle did suds first appear? How many drops of soap solution were needed to produce suds in the hard water to which the washing soda was added?

*Conclusion.* — Did the washing soda make the hard water soft? In this experiment, why is it important to use (1) the same amount of water in each bottle? (2) the same number of drops of soap solution in each bottle? Find out how many more drops of soap solution are needed to form suds in the other bottle of hard water.

Washing soda and borax combine with the minerals in hard water, changing them to substances which do not react with soap, thus making the water soft. If you add a large amount of soap to hard water, it will make the water soft, but this is more expensive than softening the water with chemicals.

The people who live along many large lakes and rivers have no problem in obtaining enough soft water for washing, as such open bodies of water are often, but not always, soft. However, for many people in other areas in Canada, getting soft water is a more serious matter. Many people collect the rain which falls on the roof by letting it run from the eaves into large water-tight *cisterns.* In winter, many homes are supplied with soft water by melting ice that has formed on hard water. The ice is free of the salts that cause hardness in water. In areas where the water is very hard, water-softening equipment is needed in each home. If you live in one of these areas, find out how the water is softened, how frequently the chemical must be regenerated, and how this is done. In what way is such equipment convenient? How does this equipment help to save money?

**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

1. Explain what is meant by the term *water cycle.*
2. Describe a method of getting distilled water from salt water.
3. (*a*) What is in hard water that makes it different from soft water?
   (*b*) In nature, how is soft water changed to hard water?
   (*c*) What causes grey scales to appear inside a tea-kettle?
4. (*a*) Why do we prefer to use soft water rather than hard water for washing?
   (*b*) What is the effect of washing soda on hard water?
5. Describe an experiment to find out whether more soap is needed to form suds in hard water than in soft water.

## WATER PURIFICATION

Tom Blair and John Thomson are fond of fishing. One Saturday afternoon in early spring they were sitting on the bank of the river, watching the floats bobbing in the water above their baited hooks.

"I don't think I ever saw the water as muddy as it is today," said John. "Last night's rain must have washed a lot of soil into the river. You'd hardly think a fish could live in such water. I wouldn't want to swim in it."

"I wouldn't swim in it either," said Tom. "But my dad says we drink water from this river."

"That's hard to believe," John asserted. "The water we get from our taps is clean. We couldn't use this

This unsightly garbage heap makes this water unsafe to drink. What kinds of impurities would probably be found in the water of this stream? (Ontario Department of Planning and Development photo)

These large siphons carry water from a river to a distant town. The siphons are made of lumber reinforced with steel bands. (Department of Agriculture photo)

river water just as it is. Look, there's a dead fish in the water, and a piece of paper." As the boys watched the water they saw many other things in it which showed it to be unclean — a paper box, leaves, sticks, and garbage. Occasionally they saw a film of oil floating on the water. Tom suggested that they take some of the water to school to show their class. They rinsed out an empty jar that they found, and filled it with the muddy water.

On Monday morning the class was very surprised at the difference between the muddy river water and the clean water that poured from the water tap.

"Is it correct that our drinking water comes from the river, Miss Peterson?" John asked.

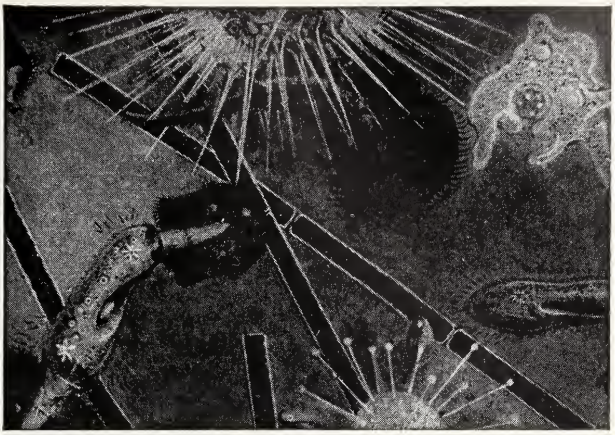
"Yes, John, it does. What takes place behind the water tap makes a very interesting story. Scientists have found ways of making water clean, safe, and pleasant to drink. At the *water purification plant* their knowledge is applied to changing the muddy river water into safe drinking water."

**Where do we get our water supplies?**

Many cities and towns, like the one in which John and Tom live, get their water supply from rivers. Montreal, Ottawa, Windsor, Edmonton, and Saskatoon are but a few of the many Canadian municipalities that use river water. Other places obtain their supply from convenient large bodies of water. Toronto, Hamilton, and most cities on the Great Lakes get their water through large intake pipes which extend far out into the lake where the water is cleaner than it is along the shore.

Most farms and villages and a few cities get their water from wells. Such water is usually cleaner than lake and river water.

Some municipalities must spend large sums of money to obtain enough water. Sometimes dams are built across rivers to form large *reservoirs* of water. A few cities must bring their water supply through a system of pipes and siphons that conduct it over hills and through valleys to the purification plant.



Some of the kinds of tiny creatures (plankton) in a drop of impure water, seen through a powerful microscope. How many different kinds can you see? (Westinghouse photo)

Cities which are built along the ocean cannot use the salty ocean water, and must therefore bring their supply from fresh inland sources. Vancouver gets its water from mountain streams. The city of New York pumps its water from a source over one hundred miles away!

**SOMETHING TO DO**

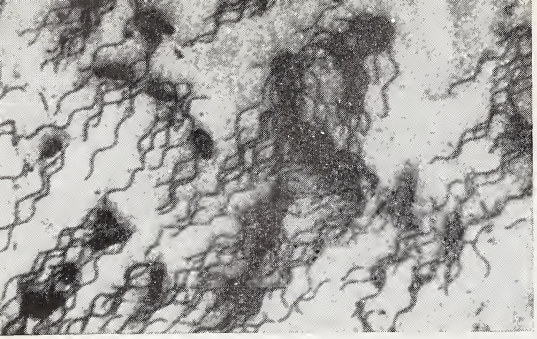
1. On a map of your province, locate the cities and towns that probably get their water supply from nearby lakes and rivers. Which places probably get their water from wells or distant sources?

2. Prepare a siphon. Stand a pail of water on a table, and an empty pail on the floor. Fill with water a piece of rubber tubing four or five feet long. Pinch both ends with your fingers so that the water cannot escape. Hold one end in the pail of water, and the other in the empty pail. Release the pressure on the ends of the tubing. What happens to the water? You can use this siphon to remove dirty water from your aquarium. In what part of the siphon does water run uphill? Why is a siphon useful in conducting water from distant sources?

### Surface water is often unclean and polluted

When Miss Peterson's class examined the river water that the boys had brought to school, they saw many kinds of impurities in it. They saw specks of soil, sticks, and leaves. The water had a cloudy, greyish-brown appearance, caused by millions of tiny particles of clay soil which had been eroded from fields and hills. John told the class of the other kinds of impurities he had seen in the river -- paper, dead fish, garbage, and oil spots. Surface water, that is, water found on the surface of the earth, as in lakes and rivers, usually contains many of the impurities that the class observed.

In warm weather, surface water usually contains millions of tiny living creatures, called *plankton,* that give



The photograph above shows typhoid fever bacteria, highly magnified. In earlier times, these bacteria were spread readily by impure water, and typhoid fever was a common disease. Why is typhoid fever not a common disease today? (General Biological Supply House photo)

the water a cloudy appearance and sometimes a foul taste. Plankton includes many kinds of simple, often one-celled, animals. Pond water in summer often contains, in every drop, hundreds of these tiny, swimming creatures. Plankton provides food for many kinds of fish, but is undesirable in our drinking water.

Another, and a much more dangerous condition found in most surface water is the presence of *bacteria* (germs) which can cause diseases such as typhoid fever and intestinal flu. Bacteria are plants, so small that they cannot be seen without the use of a powerful microscope. It would take thousands of these bacteria to cover the period at the end of this sentence. Water which appears clean may be polluted by sewage containing millions of them. In water, disease bacteria can reproduce and spread very rapidly. On a warm summer day one germ can become several hundred. Before men learned how to purify water, many epidemics were spread by water polluted with disease bacteria. Since we have learned to control and destroy bacteria in water, such epidemics have become less common. Typhoid fever has been almost wiped out in our country because of the work of scientists who have learned how to destroy the bacteria in drinking water.

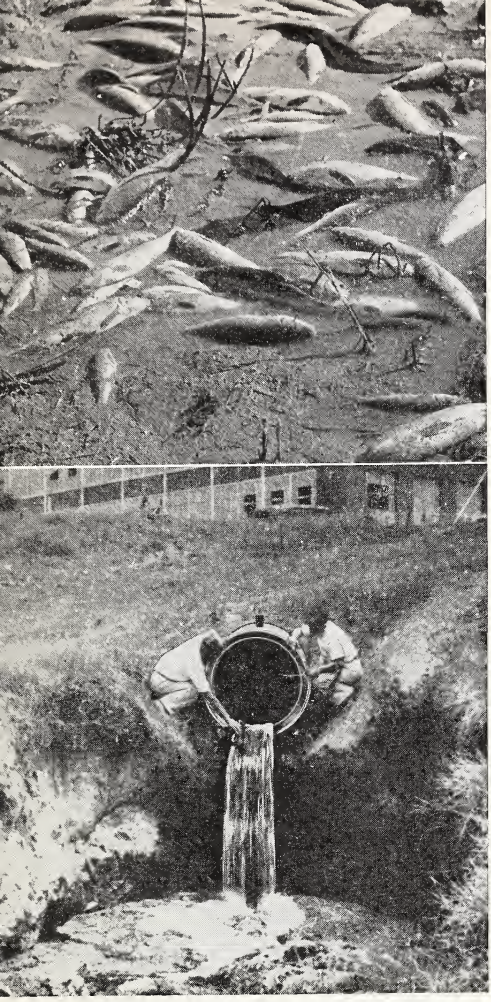
### How do disease bacteria get into the water?

Every town and city has to have a means of getting rid of sewage. In rural areas, sewage is often treated in septic tanks and cesspools in the ground. In cities and towns there is not enough room to treat sewage in this way. Some municipalities empty the untreated sewage into the nearest lake or stream. This sewage contains hordes of bacteria, and wastes that the bacteria use for food. In the water, the bacteria reproduce and spread rapidly. The polluted water may be taken back into the city's water system, or it may flow downstream and contaminate the water supply of other communities.

To prevent pollution of surface water by sewage, many cities and towns pass their sewage through a *sewage disposal system* which destroys the harmful bacteria and removes the solid wastes before the remaining liquid enters the lake or river.

### Other impurities in water

Many factories empty such waste products as sour milk, dyes, oil, and



Top: These dead fish, found along the shore of a small river, were killed by pollution from a nearby factory. Bottom: Scientists take from a factory, samples of sewage, which will be tested to see if it contains poisons. (United States Fish and Wildlife Service photos)

various chemicals into lakes and streams. Many of these wastes are poisonous, and they often kill fish. Factories should develop methods of getting rid of these poison wastes without emptying them into surface water supplies.

You have already learned that the water in some areas contains many dissolved minerals. This hard water is usually satisfactory for drinking, but often has to be treated in the home to make it better for washing.

### How are impurities removed from our drinking water?

Perhaps you are shocked at the variety of impurities in the sources of municipal water supplies — garbage, soil, plankton, and bacteria from untreated sewage. Before water is clean and safe to drink, these impurities must be removed or destroyed. This is the work of the *water purification plant.*

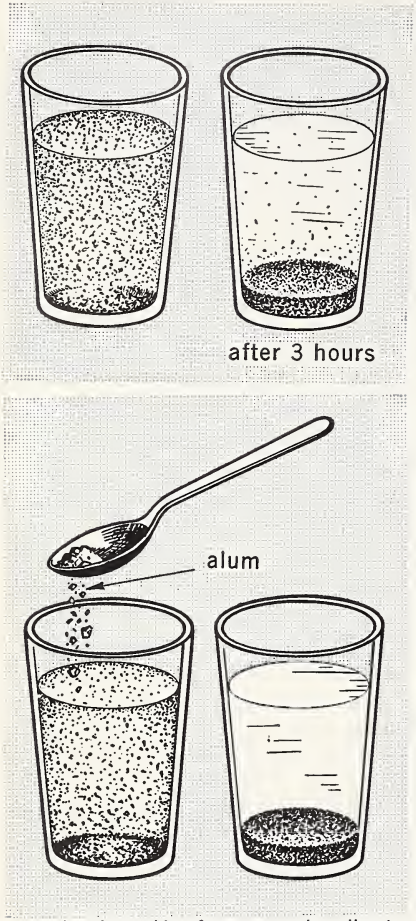
#### SOMETHING TO DO

If you live in a town or city, or in a village which has a municipal water system, visit your water purification plant. If you live in a rural area, visit the water purification plant in the nearest town. Find out the source of the water and the methods used in removing soil and plankton, and in destroying bacteria.

In a purification plant, the coarse impurities such as dead fish, garbage, leaves, and sticks are removed by a screen through which the water flows from the intake pipe.

### Removing soil and plankton by settling

After the coarse impurities have been removed from the water, the




Removing impurities from water by allowing them to settle. What effect does dissolved alum have on the plankton and the fine particles of soil?

next important step is to dispose of the soil and plankton in the water.

#### SOMETHING TO DO

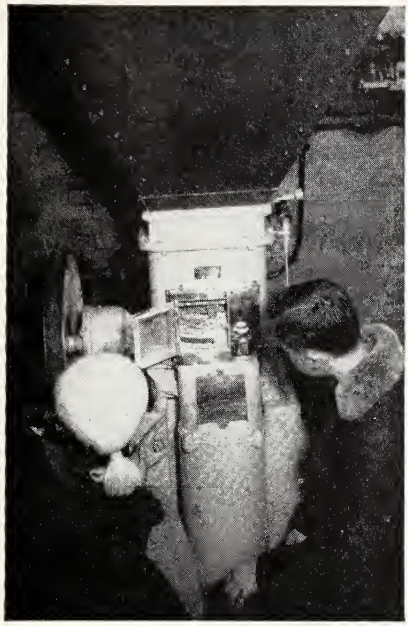
Fill a clean jar with muddy water. Let the water stand for several hours. What difference is seen? Why did the particles of soil settle to the bottom? You should recall that soil is made up chiefly of tiny particles of rock.

Buy a few cents' worth of *alum* at a drugstore. Add a few of the white crystals to a bottle of muddy water. Shake it thoroughly to dissolve the alum, and then let it stand for several hours. You should observe it every half-hour. What effect did the alum have on the particles of soil?

In the purification plant, alum is added to the water in carefully measured quantities. The alum soon dissolves in the water. The water is then allowed to stand for several hours in a very large *settling tank*. The heavy soil particles quickly settle to the bottom. The alum causes the tiny particles of soil to stick together, forming larger particles which also settle to the bottom. Much of the plankton is removed in the same way. The water is now fairly clear, but another step is needed to remove the remaining cloudiness.

### The work of the filters

The soil and plankton which are not removed in the settling tanks are strained out by the *filters*. A filter is a tank the size of a large room, with pipes in the bottom to carry away the water. Over the pipes is a layer of stones, then there are layers of coarse gravel, fine gravel, and finally about three feet of clean, fine sand. Water from the settling tanks flows over the top of the sand in the filters and quickly soaks down through it. The fine sand will not let the particles of



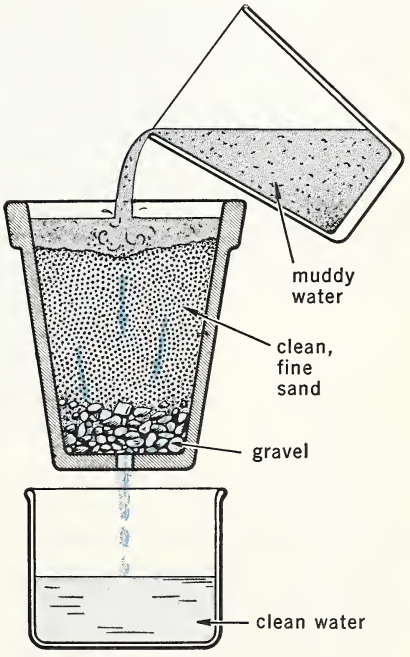
At the water purification plant, this machine adds measured amounts of alum to the water. (H. Murray and A. Stecher photo)

soil and plankton in the water pass through it, and they are caught on the top of the sand. After the water passes through the filter, it appears very clear. Most water purification plants need several filters to strain out the impurities in the large amounts of water used by the municipality.

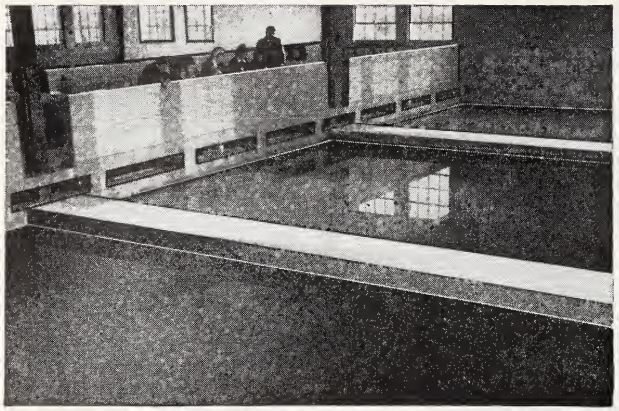
After some time, the filter will not work because the top of the sand becomes clogged with soil and plankton. To clean the filter, water is pumped upward through it, causing the impurities to float free of the sand so that they can be carried away in a waste pipe. The clean sand is then allowed to settle back into place where it is again ready to filter impurities out of the water.

#### SOMETHING TO DO

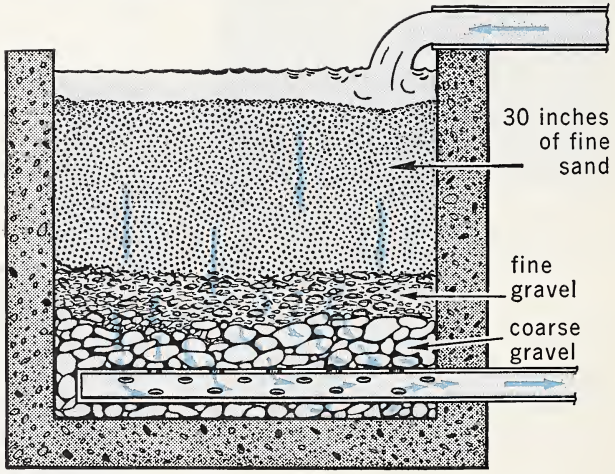
Make a classroom filter like the one illustrated below. Use your largest flower-pot or a large can or pail with holes punched in the bottom. Pour muddy water over the clean, fine sand, and catch the water that filters out of the bottom. Compare the filtered water with the muddy water. Was any cloudiness left in the filtered water? Why is as much as three feet of sand used in the filters that help to purify our drinking water?




A small filter that you can make to study the effect of clean, fine sand in removing impurities from water.



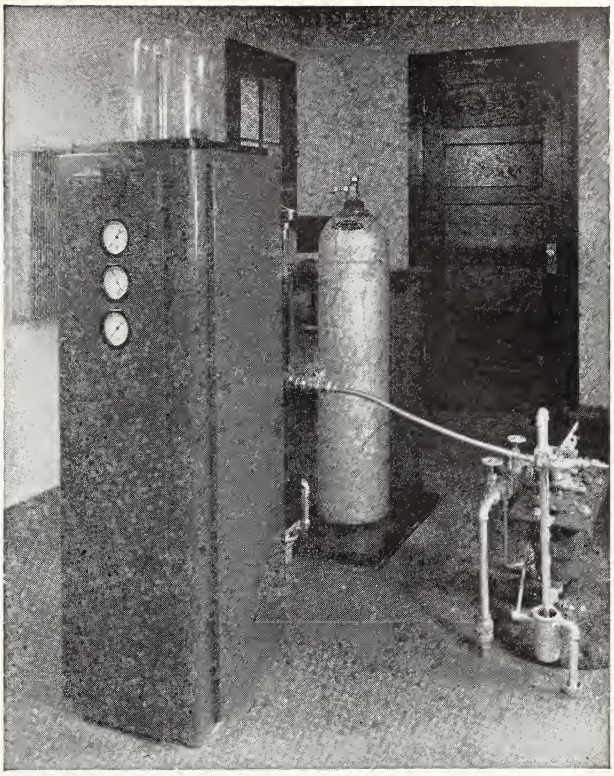
Three large sand filters in a water purification plant. (H. Murray and A. Stecher photo)




A cross-section of a large sand filter. Compare this filter with the one shown at the bottom of page 281.

**Destroying bacteria with chlorine**

Many of the bacteria in the water are not removed by the filters. Killing these disease bacteria is the most important step in water purification. To kill disease bacteria, *chlorine* is added to the water in small, scientifically controlled amounts. Chlorine, a greenish-colored gas, is a deadly poison, but only enough is added to the water to kill the bacteria. This small amount is harmless to humans. Sometimes you can smell the chlorine used in purifying the water. At the purification plant, samples of the chlorinated water are tested several times daily to find out if enough chlorine is being added to destroy all the harmful



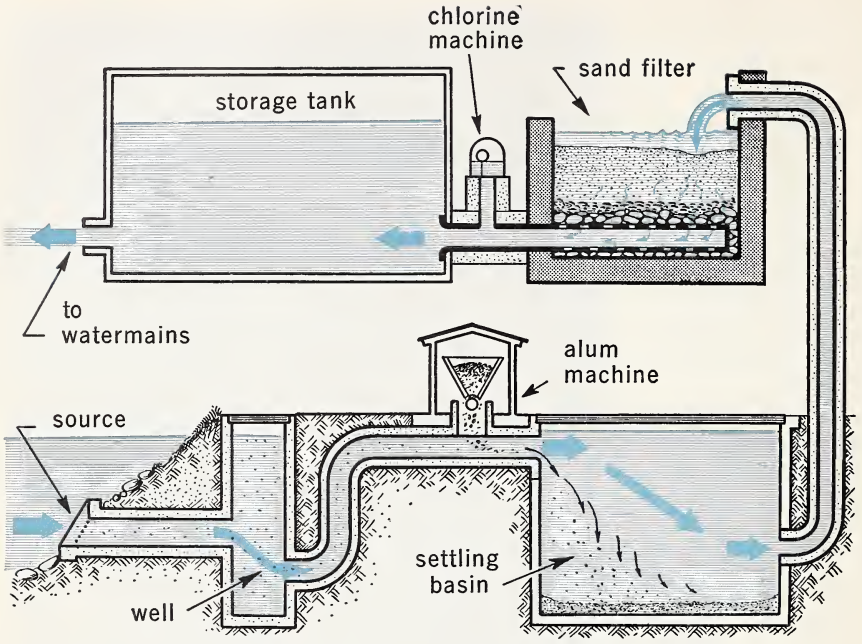
This machine adds chlorine to water in controlled amounts. Chlorine is shipped as a liquid in cylinders like the one shown. As the pressure is released, it changes to chlorine gas. Why is this machine sometimes called "the heart of the water purification plant"? (Wallace and Tiernan photo)

bacteria. The chlorine may be added to the water during any part of its purification but is usually added after the water has been filtered.

The water at some purification plants is *aerated*, or sprayed into the air so that it can absorb oxygen, which removes unpleasant odors from the water. The air which is absorbed also overcomes the flat taste that may be present.

After our water supply has been purified, it is allowed to stand for several hours in a huge storage tank to give the chlorine time to destroy all the bacteria. The storage tank holds enough water for emergencies when large amounts are required. From the storage tanks, water is pumped under pressure through the water mains to our water taps.

You may be surprised to learn that the average Canadian living in an area with a municipal water supply uses over one hundred gallons of this essential liquid each day. Some municipalities purify enough water for more than two hundred gallons a day




A diagram of a water purification plant. Follow the path taken by the water from the time it leaves the source until, as safe, clean water, it enters the water mains. Explain how each part helps in purifying the water.

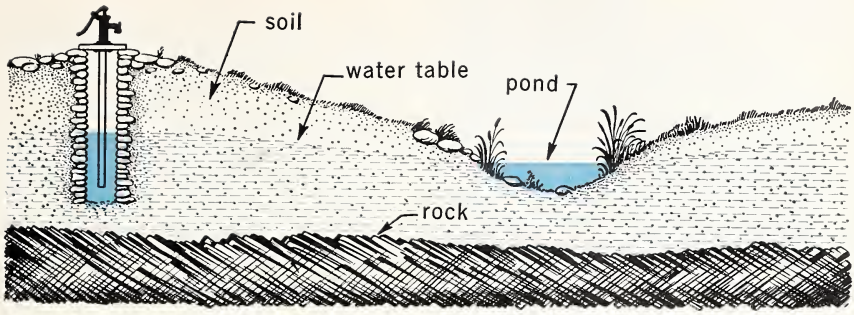
for each citizen. Much of this supply is used in industries, in washing streets, in fighting fires, and in watering our lawns and gardens.

### A safe supply of farm water

One of the essentials of a farm home is a source of water that will be clean, safe, and adequate throughout the year. Several kinds of wells are used, depending on the depth at which water is found in the ground. A *dug well* or *shallow well* is dug twenty or thirty feet into the ground, and provides water which has filtered down from the surface of the ground. A *driven well* is made by driving pipes much deeper into the soil, where they finally reach a source of water. *Drilled wells* are constructed by fitting pipes into holes that have been drilled down through the first layers of rock under the soil, to a level where a dependable supply of water is found.

### How does water get into a well?

Dug wells are the most common kind in most parts of Canada. Because they may contain water that




In a dug well, the surface of the water is at the water table. How does water enter the well? What would happen to the level of the water in the well if the pond were drained?

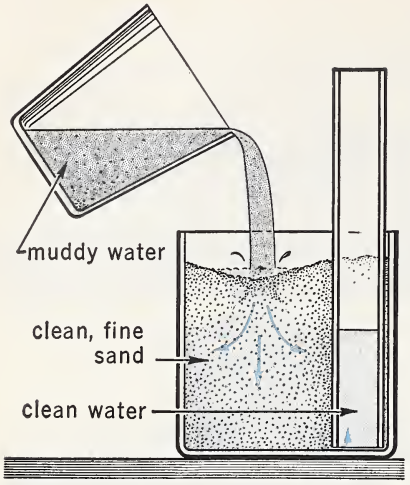
comes from the surface of the ground nearby, they are in more danger of contamination than other kinds.

If you look back at the drawing of the water cycle on page 270, you will see that some of the rain soaked into the soil. This *ground water* continues to sink into the soil until it reaches a layer of rock through which it cannot pass, as shown above. The spaces between the soil particles become filled with water. The top of the ground water is called the *water table*. At places where the top of the ground is lower than the water table, the water appears above the ground as a lake, pond, or marsh. The water table in the surrounding higher ground may be at the height of the water in the pond, or it may be slightly higher, depending on the size of the soil particles.

If a well is dug into the ground so that it extends below the table, water from the soil seeps into it. The top of the water in the well is at the height of the water table.

**Unsafe and safe construction of wells**

Last summer, Helen Smith's family moved to a farm outside of town. Helen and her mother did not like the taste and odor of the water from the farm well. Mr. Smith decided to examine the well to see if he could find the cause of the disagreeable qualities of the water. He found several faults with the well. It had been dug at the edge of the barnyard. The ground at the top of the well was slightly lower than the level of the barnyard. During a rainstorm, Mr. Smith noticed that water from the barnyard drained toward the well. He knew that animal wastes often contain harmful bacteria, so he examined the well more carefully to see if any of the surface water from the barnyard could enter the well. He noticed that the boards covering the top of the well were rotten, cracked, and loose. When he lifted one of the loose boards he found that the brick walls of the well were badly cracked,



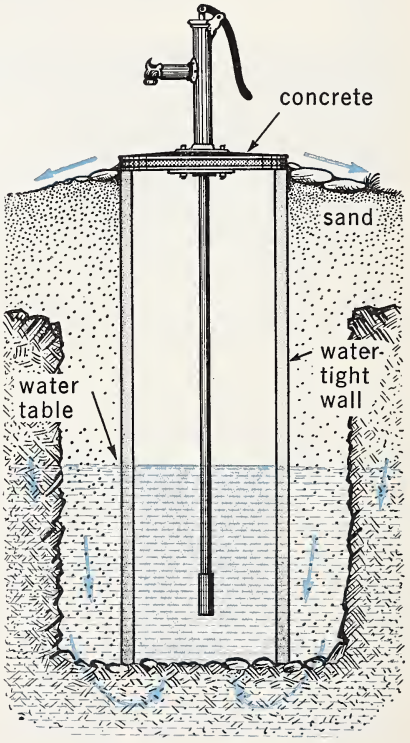

Explain how surface water, such as rain, enters a well. How are impurities removed from the water that enters a well?

and that water was running into the well through many of the cracks near the surface of the ground.

The Smiths immediately decided to discontinue using the water. They sent a sample to their local Department of Health to be tested. In the meantime, they obtained good drinking water from a neighboring farm where the water had been tested recently.

The report from the Department of Health showed that the water from the poorly constructed well on the Smith's farm was unfit for domestic use because it contained sewage and harmful bacteria.

Mr. Smith decided to build a new well like the one shown at the right. A well of this kind should be dug on ground higher than barnyards and outdoor toilets, and at a safe distance from them. The upper part of the well should be water-tight, and the top should be covered with concrete. The ground around the top of the well should slope away from it. To enter such a well, surface water must filter through many feet of fine sand, which removes the impurities.

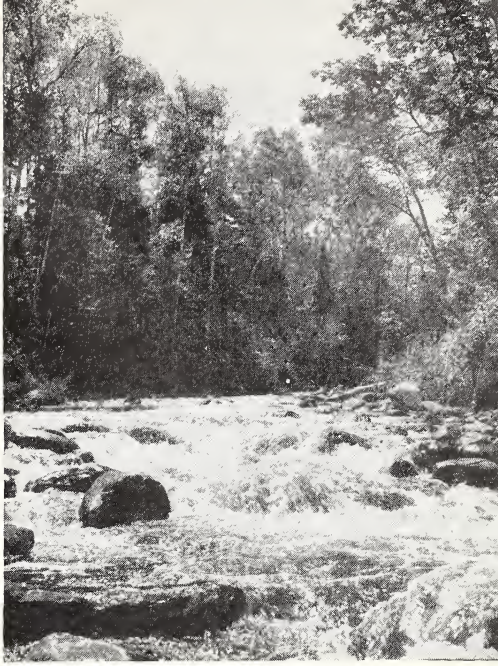



The diagram above illustrates a carefully constructed well. Why is it covered with a concrete slab? Why should the wall be water-tight? What purpose is served by the sand?

**SOMETHING TO DO**

1. Prepare the equipment shown at the top of page 286 to find out how water enters a well. Be sure to use fine sand, and to wash it thoroughly before putting it in the beaker.

2. If you live on a farm or attend a school where water from a well is used, arrange to have it tested by your local Department of Health or by the Department of Health at your provincial capital. Send a sample of the water in a clean, sealed, carefully wrapped jar. There is no charge for this service. Some provinces require that the water from school wells be tested at least once a year.



Although the water in this stream appears clean, it may contain disease bacteria. If you were camping near this spot, how could you make the water from the stream safe to drink? (Ontario Hydro photo)

## Safe water at camp

Jack Hopkins and several other Boy Scouts were camping out for a few days during the summer holidays. They selected a camp site in the woods, beside a clear, bubbling stream. They had brought plenty of food with them, but needed water for drinking and cooking. They examined the water in the stream, and finding that it appeared clear and clean, they assumed that it was safe to drink. Two days later three of the boys were ill and had to return home. Their doctor told them that they had mild attacks of dysentery, probably caused by bacteria in the untreated water. In what way had the boys acted unscientifically? Is water which appears to be clean always safe to drink?

There are two simple ways to purify water at camp or at a summer cottage. Boiling drinking water destroys the harmful bacteria, but leaves the water with a flat taste. Adding chlorine, procurable in tablet form at any drug store is easy and effective. You should not use untreated water until it has been tested by your Department of Health.

**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

1. (*a*) What are the most common sources of the water supplies used in cities?

(*b*) Why is it necessary for ocean ports to get their water from inland sources?

2. Name three impurities which often can be *seen* in surface water.

3. (*a*) Why are the invisible impurities more dangerous than the ones we can see?

(*b*) How do disease bacteria get into surface water?

4. Describe the method used at the water purification plant in destroying or removing each of the following impurities:

(*a*) coarse materials such as dead leaves and twigs

(*b*) coarse particles of soil

(*c*) plankton

(*d*) disease bacteria

5. Describe an experiment to test the effect of alum in causing soil particles in water to settle.

6. Draw a cross-section of a filter. Use arrows to show the direction of flow of the water.

7. Make a cross-section drawing of a good farm well.

8. How can we purify surface water when we are at camp?

## CONSERVATION OF WATER

We have learned that water has a host of uses — for domestic purposes, growing plants and raising livestock, manufacturing, disposal of sewage, transportation, fishing, and recreation. Sometimes the unwise use of water for one purpose makes it unfit for other uses. For example, emptying untreated sewage into rivers makes the water unsafe for swimming and drinking. Factory wastes kill fish and other wildlife that depend on water; in turn the water loses its value as a tourist attraction.

Two of nature's reservoirs are natural ponds, and moist, spongy forest soil. How is the water table affected by draining ponds and cutting forests? What are some other harmful effects of these practices? (Ontario Department of Planning and Development photos)

Today, with an ever-increasing demand for water for farming, manufacturing, and domestic uses, we should be very conscious of the necessity for water conservation. Frequent spring floods, and streams laden with soil and sewage are evidences of the fact that water is not being used wisely. The summer shortage of water in towns and in farm wells points to a need of storing more of the water that falls as rain. Barren farmlands, abandoned because they cannot hold enough moisture to grow crops, show the serious results of scarcity of water.

A man-made pond conserves water that otherwise would run off the soil in spring. This pond keeps the soil moist and provides water for livestock and farm poultry.

### Nature's reservoirs

When the white men first came to this continent, they found a plentiful supply of fresh, clean water in the lakes and streams, fed by the rain which fell in the great forests and grasslands. When rain falls on trees and other plants, it drips gently to the ground, to be absorbed by the roots and the loose, spongy soil.

In the forest, snow melts more slowly than it does in bright, open fields, and the water soaks into the ground instead of rushing away in a spring flood.

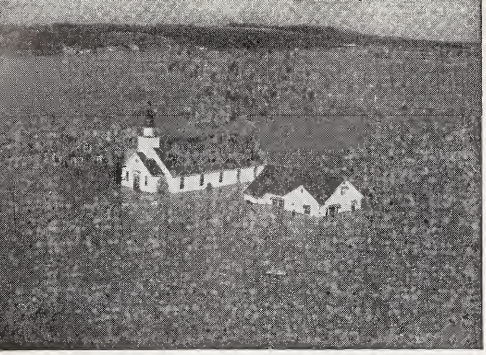
#### SOMETHING TO DO

1. When you are walking in a forest, notice the looseness of the soil. Do you feel as if you are walking on a thick rug?
2. Scrape the dead leaves from a spot on the forest floor and dig up a handful of the loose soil. Is it moist? Is it at the same temperature as the air? What evidences of decayed plants can you see in the soil?

After man has cleared the forests from the hillsides, rain water is not absorbed by the soil, but runs along the top of the ground. As it hurries along, it picks up soil and soon becomes a muddy stream. To prevent this kind of *soil erosion,* it is necessary to leave hillsides and river banks under a cover of trees or grass.

The soil in the forest is one of nature's reservoirs. Others are swamps, marshes, and ponds. These reservoirs store up large quantities of water in spring, releasing it slowly throughout the summer.

It has been found that when ponds, swamps, and marshes are drained, the water table in the soil of the farms nearby becomes too low to provide moisture for crops. Today many farmers are restoring marshes and building farm ponds and dugouts to help maintain the level of the water table, and to provide water for their livestock.



This flood, which occurred a few miles north of Toronto, damaged many buildings, destroyed valuable crops, and covered the soil with harmful silt. What are some ways of reducing the danger of floods? (Ontario Hydro photo)

In some dry areas, efforts must be made to save all the water that falls as rain or snow. In the previous chapter, also, you learned about the conservation of water in soil.

**Flood prevention**

In recent years there have been serious floods in many parts of Canada. Although some of these floods could not be prevented, they could be made less destructive by wise conservation practices.

Floods are caused when the soil is unable to absorb the water from melting snow and heavy spring rains. As the water runs downhill, it forms a stream. As dozens of these rising streams pour into the river, the swollen water rises over its banks, flooding the level ground and causing great damage to property and sometimes taking a heavy toll of lives.

By reforesting bare hills, and keeping sloping ground in grass, we can help the soil absorb the rain as it falls. In the small streams that feed the larger rivers, small dams can be used to hold back the rising waters. Beavers slow up the movement of water in these tributaries by building dams. In some streams, men build larger dams to hold back a portion of the flood water.

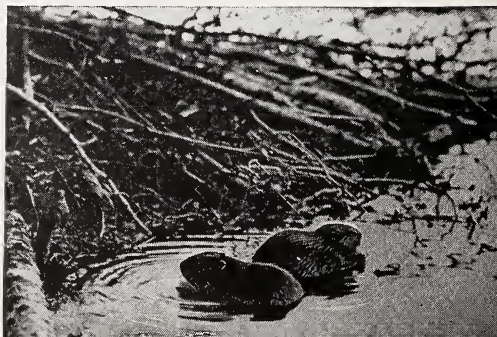
**Working together to conserve water**

Because we all use large amounts of water, its conservation is the concern of everyone.

In our homes, we can conserve water by making sure that water taps are turned off when not in use. A dripping tap can waste as much water in a week as one person uses in two days.

Today, many people are working together to plan the wisest use of our water supply. In the Prairie Provinces, where the success of crops is dependent on the supply of moisture, special care must be taken to conserve all the water that falls as rain and snow, and to obtain, in many areas, additional water from lakes and rivers. The Prairie Farm Rehabilitation Act (P.F.R.A.), has given farmers impetus to co-operate in the

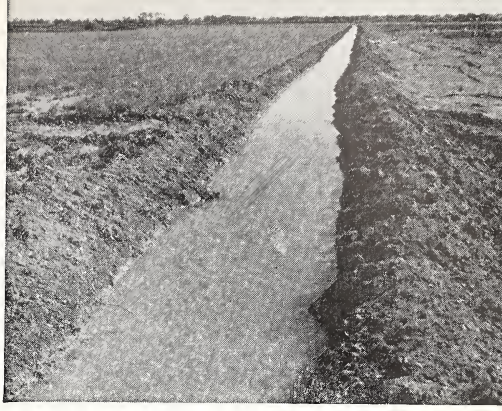
Nature's engineers at work on their dam. How do beavers help to conserve water and prevent floods? (National Film Board photo)



study and application of methods of saving moisture. *Small dams and dugouts* are being built to provide water for individual farms or to serve groups of farms on a community basis. By these smaller projects, surface run-off from melting snow and heavy rains is stored for use in times of drought, for watering stock, for irrigating gardens, and for household purposes. It has been estimated that 35,000,000 acres of land in Canada's western provinces can be irrigated by these means. The construction of *large dams* in rivers provides water for irrigation purposes for the surrounding area.

*Summerfallowing* is another water conservation practice used widely in Western Canada. Part of the land is left without a crop for one year, and is cultivated just enough to control weeds. In this way, the moisture of the summerfallow year is stored up in the soil, and the crop the following summer receives the advantage of two years' moisture. On pages 251 to 253, you learned about summerfallowing and P.F.R.A. projects carried out for the purpose of conserving water and soil.

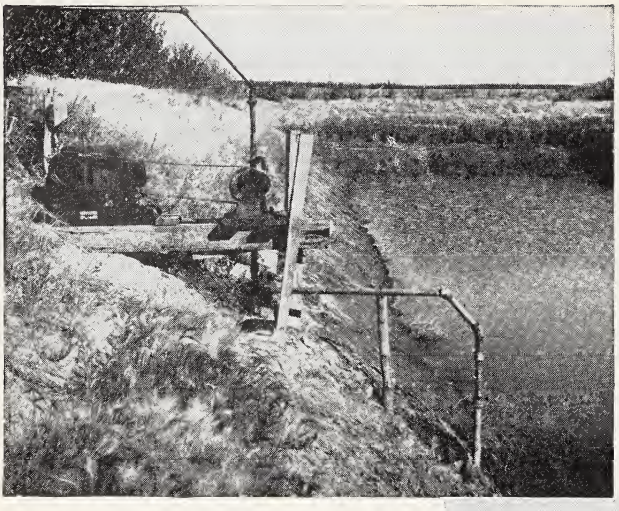
In Ontario, the people living in the various valleys are working with their neighbors to solve their water problems. The River Valleys Authorities Act was passed to encourage people to work co-operatively in conserving water, soil, and forests in each river valley. In the Ganaraska River valley, many large reforestation projects have been started to prevent floods, hold the soil in place, and maintain



An irrigation canal near Pike Lake, Saskatchewan. How is the water in the canal made available to crops? Look at the illustrations on pages 252 and 253. (National Film Board photo)

the water table in the soil. Dams along the Grand and Thames Rivers help prevent floods in the valleys of these two rivers.

One of the finest examples of a community conservation project is in the valley of the Don River, which flows into Lake Ontario at Toronto. The residents of the *watershed* that is drained by the Don River are working in co-operation with government agencies to conserve soil, forests, water, and wildlife. Several reforestation projects have been planned and undertaken. The construction of dams will result in the formation of artificial lakes which will provide water for recreation and will assist in preventing floods. Efforts are now being made to reduce the pollution of the river water. In time, this valley, though running through a thickly populated city, will become a place of natural beauty, with green forests, fish, waterfowl, and clear, sparkling water (see also page 293).



Left: Pumping water from a dugout to irrigate a farm garden in Saskatchewan. Below: Dugouts also provide water for livestock. (Left, Department of Agriculture photo; below, Ontario Department of Planning and Development photo)

Conservation of water is closely linked to our use of other resources. If we keep our hillsides under forest cover, reforest our waste lands, protect our fields from erosion, and treat our sewage and factory wastes properly, we shall have steadier stream flow, a better quality of drinking water, more fish and wildlife, and more water for farming and industry. Forests, wildlife, good soil, and clean water are closely related. Let us all help conserve water!

#### SOMETHING TO DO

1. Give a report on the water conservation projects being carried on in your community.

2. Visit a pond and find out how it helps to maintain the water table in the surrounding fields. Dig a hole in the ground a short distance from the pond, and find the water table.

3. Visit an area where reforestation is being carried on. Perhaps you can help to plant some trees.

4. In dry weather, compare the dampness in samples of soil from a sloping field and from the forest floor.

5. Make a map showing the watershed of the stream nearest your home or school. Mark all the smaller streams and drainage ditches that flow into it. Show where flooding occurs. Where might dams be built to prevent flooding? What other flood prevention methods could be used?

**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

1. Whether we live in town or on a farm, water conservation is important to us. Why?

2. What undesirable conditions come about when water is not conserved (*a*) on farms, (*b*) in cities, and (*c*) in lakes and streams?

3. (*a*) Explain three ways in which forests help in the important work of water conservation.

(*b*) Of what value are ponds and marshes?

4. Game fish cannot live in streams that become muddy with eroded soil. How can farmers and lumbermen prevent soil erosion on stream banks and hillsides?

5. Describe two conservation practices that help to prevent floods.

6. Why is the beaver sometimes referred to as "nature's water conservationist"?

7. What is a dugout? How does a dugout conserve water in dry areas?

8. Explain how summerfallowing conserves moisture.

9. Describe an example of community planning for water conservation.

A group of pupils who live in the Don River Valley, on a field trip to study conservation plans in their valley. Their teacher is showing them the future location of a dam that will cause a lake to form behind it. Of what value will this lake be to the residents of this valley? (Ontario Department of Planning and Development photo)

## WHAT HAVE YOU LEARNED?

### IMPORTANT SCIENCE IDEAS AND UNDERSTANDINGS

A

1. Water is found almost everywhere, in one or more of its three forms: ice (a solid), water (a liquid), and water vapor (a gas).
2. Water has many important uses — for domestic purposes, farming, producing power, manufacturing, transportation, recreation, and carrying away wastes.
3. An adequate supply of clean, safe water is one of our basic needs.
4. Water that contains various dissolved minerals is called hard water.
5. For washing, soft water is much better than hard water.
6. Most surface water contains several kinds of impurities.
7. The most dangerous impurities found in water are the invisible disease bacteria which usually enter the water in untreated sewage.
8. Chlorine added to water will kill harmful bacteria.
9. When water is still, most of the heavy particles settle to the bottom.
10. Filters strain the fine particles of dirt out of our drinking water.
11. Farm wells should be built far away from and on higher ground than barnyards and toilets.
12. Forests help maintain a steady flow of clean water.

(a) The foregoing sentences are all true statements of important science ideas and understandings. Read and discuss them carefully as a review of this chapter.

(b) The following sentences describe situations in which some of these ideas apply. To test your ability to apply ideas to actual situations, match the sentences in A with sentences in B to which they apply.

B

1. At the purification plant, the water is passed through three feet of sand.
2. Malcolm Gray visited a large limestone cave that was formed by the action of water.

3. When Mrs. Flaman used water from the well for washing her dishes, she had to use a large amount of soap.

4. When the class visited a water purification plant, they learned that several feet of soil, plankton, and other impurities collect each year in the bottom of the large settling tank.

5. Tom Blair has learned that trout can be found throughout the summer in the cool forest streams.

6. Epidemics of typhoid fever, once very common, have almost disappeared since modern water purification methods have been introduced.

## IMPORTANT SCIENCE TERMS

### A

| | | |
|---|---|---|
| irrigation | water cycle | plankton |
| dissolve | distilled water | pollution |
| solution | washing soda | chlorine |
| soft water | alum | filter |
| hard water | siphon | water table |
| bacteria | ground water | reservoirs |

To show that you understand and can use the science terms in A, match with the situations described in B those terms which apply.

### B

1. Much of the water vapor that evaporates from the Pacific Ocean falls as rain on the western side of the Rocky Mountains.

2. When Mr. Shaw was digging post-holes near his pond, water ran into them. The top of the water in the holes was at the same height as the water in the pond.

3. When the pupils in Miss Peterson's class were at the water purification plant, they saw a machine in which a green gas was bubbling through water.

4. In June, the pupils found that the water in the pond teemed with tiny swimming creatures.

5. Mr. Olson must replace the water that evaporates from his car battery with water containing no minerals. To get the right kind of water he catches rain water in a glass dish.

6. John Thomson was surprised to learn that clear water often contains many harmful living things.

7. Many farmers build ponds and dugouts to store up some of the water that falls as rain and snow.

8. Many dry areas would become rich farmland if we could supply them with enough water.

**SCIENTIFIC METHOD AND ATTITUDES**

1. Mr. Lucas cut down his forest and drained a marshy pond on his farm so that he would have more space for growing crops. In a few years, he noticed his crops drying up in mid-summer.

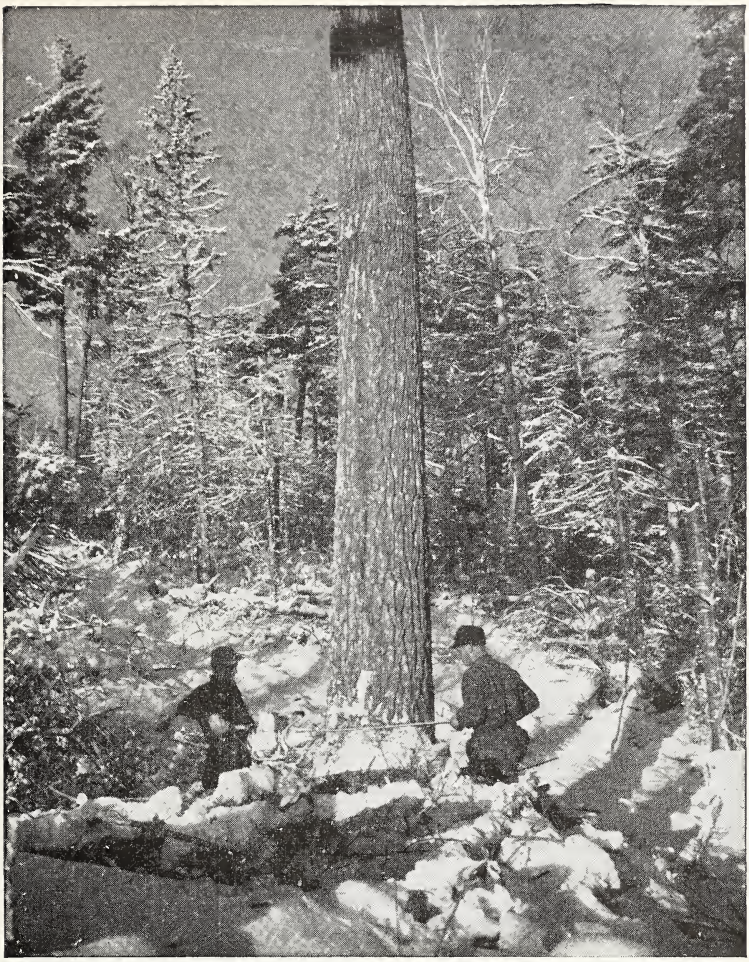
"Probably we don't get as much rain as we used to," he explained. When a neighbor told him that the weather office, which makes accurate measurements, had found very little difference in the amounts of rainfall, Mr. Lucas said their findings were wrong, because he could see for himself that the land was becoming drier each year. When several neighbors told him their crops were not drying up, Mr. Lucas said, "Well, it looks as if I'm just unlucky in getting less rain than you."

(*a*) What do you think caused Mr. Lucas' land to become much drier?

(*b*) What scientific attitudes did Mr. Lucas fail to show in his explanations?

2. When a group of boys went camping for a week, they took enough drinking water to last them for only two days. They wondered if the clear water in a nearby pond was safe to drink. To solve this problem they decided to try an experiment. Half of the boys decided to drink the water they had brought. The others agreed to try the pond water for four days. If they did not become ill, all of them would then use the pond water.

Do you think the boys were wise in trying to solve their problem in this way? Why? Is an experiment *always* the best way to solve a problem? How should the boys have found out if the water was safe? How can campers make water safe to drink?



Ontario Department of Lands and Forests

*The wealth of our nation depends largely upon our natural resources. These resources are ours to hold, to use, and to conserve, so that in years to come our people will continue to be prosperous.*

—*Selected*

CHAPTER 9

CHAPTER 9

# USING OUR FORESTS WISELY

Our forests are among our most important natural resources. Which of our basic needs do they help to supply? In what ways are trees and people alike? Do forest trees have flowers? Generally speaking, "hardwood" trees have broad leaves and "softwoods" have needle-shaped leaves. Can you identify five kinds of trees belonging to each of these groups? Forests aid greatly in the conservation of water, soil, and wildlife. How? Our forest industries are an important source of employment and wealth to Canadians. In what ways has the source of this wealth been endangered? What can you do to help protect our forests? How have scientists contributed to the conservation of our forests?

EVERY BOY AND GIRL of school age knows what a tree is. Indeed it is quite likely that you knew a tree by sight before you were able to talk. While still a young toddler, you understood that on a hot summer's day it was easier for you to keep cool and comfortable if you sat in the shade of the friendly old maple in the yard. While still quite young, you eagerly watched each spring for the return of the robin and house wren and observed them with keen interest as they built their nests and fed their young in nearby trees. No doubt you have had fun climbing some of these trees or swinging on a swing attached to a stout horizontal branch.

Many boys and girls in areas where the sugar maple thrives have been thrilled each spring to hear that "the sap's running." They have had the fun of helping to tap the trees, gather the sweet sap, and boil it down into that most delicious of foods — maple syrup.

It has been a thrill, too, to watch the buds of trees burst into a mass of soft green leaves and to see the fruit trees loaded with blossoms, and later with tasty apples, cherries, peaches, and other sweet, juicy fruits.

In autumn you have watched the squirrels gathering and storing a supply of nuts from the beech, and winged fruits from the maple and

ash, for food in winter. You have seen the leaves of the trees and shrubs in the valleys and forests turn to rich reds and gorgeous yellows, browns, and purples as summer draws to a close. And again in winter you have seen the spruce, pine, and fir and other evergreens piled high with light blankets of snow and the weeping birch dressed in a bridal veil of hoar frost. Whether it be spring, summer, autumn, or winter, trees are wonderful plants to know.

What a privilege it has been for many boys and girls to camp out at night. Under the towering pines of a forest, with a thick bed of pine needles beneath them, a full moon casting a pattern of light and shade on the forest floor, and the air scented with the odor of pines, firs, and wild flowers, they have been lulled to sleep in their tent or cabin by the lapping of water on the shore of a nearby lake, the strumming of a partridge, or the distant call of a loon.

Among the trees are the largest, the oldest, and the stateliest of all living things in the world. Regardless of size or age, all trees are your friends.

Winter wonderland. Trees often are as beautiful in winter as in summer, especially when covered with hoar frost. (R. H. Macdonald photo)

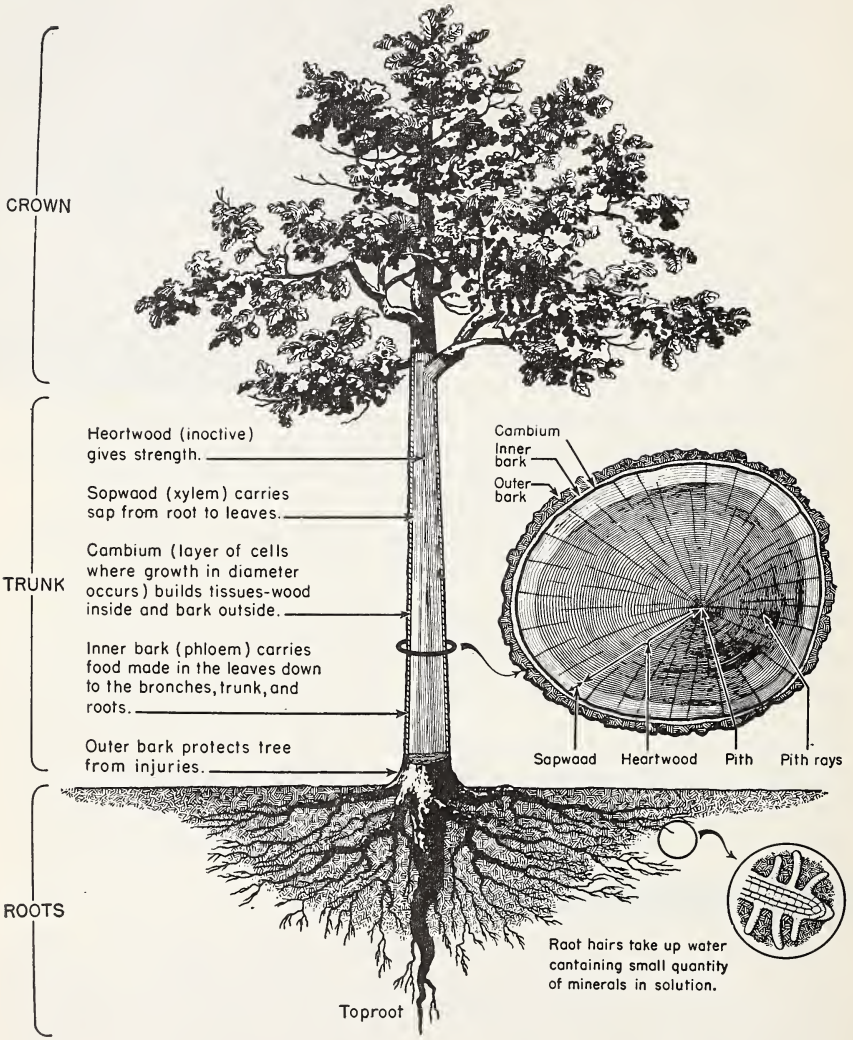
You should learn to know the different kinds of trees so that you can recognize them in your garden or orchard, along the highway, or in the park or forest.

Trees need you as their friend, too. Although you are not very big or very old, you can do much to protect and conserve them so that they will be here for the boys and girls of future generations to enjoy as you have.

## TREES ARE WONDERFUL PLANTS

Many of the trees growing today in our forests were towering giants when Christopher Columbus reached North America. Some have been growing for more than a thousand years and have reached tremendous heights. All trees, regardless of kind, age, or height, are plants. They have roots to anchor them and to gather water and food materials from the soil, stems or trunks to support the branches, and leaves to manufacture food. Trees also bear flowers, fruits, and seeds just as other flowering plants do, and they have them for the same purposes.

## HOW A TREE GROWS


CROWN
TRUNK
ROOTS
Heartwood (inactive) gives strength.
Sapwood (xylem) carries sap from root to leaves.
Cambium (layer of cells where growth in diameter occurs) builds tissues-wood inside and bark outside.
Inner bark (phloem) carries food made in the leaves down to the bronches, trunk, and roots.
Outer bark protects tree from injuries.
Cambium
Inner bark
Outer bark
Sapwood
Heartwood
Pith
Pith rays
Root hairs take up water containing small quantity of minerals in solution.
Taproot

Trace the course of water from the soil to the leaves. In the leaves, water and carbon dioxide are put together to form sugar and starch. Follow the course of the sap from the leaves to the roots. (United States Forest Service photo)

A tree has much in common with you also. In order to live, it must breathe all the time, day and night, winter and summer. It needs food to nourish it. At night it rests from its daily work of manufacturing food. Just as you have arteries to carry food to the cells of your body and veins to carry waste products back to the lungs, so too, trees have tubes to carry sugar and other foods that are made in the leaves to all parts of the tree. In trees, as in people, these foods are used to supply energy for growth and other activities. In order to thrive and grow, you require water, air, food, sunshine, and warmth; and so does a tree.

Like boys and girls, trees sometimes suffer cuts, bruises, burns, and broken limbs that require first-aid treatment by a kind friend or a "tree surgeon."

There are some ways, also, in which trees and people are quite different. Trees are rooted to the soil; therefore they cannot travel from place to place as you are able to do. Trees are dormant in winter, growing only in spring and summer. Boys and girls are active the year round and may increase in height and weight during any season. With the aid of sunlight, the green leaves of trees manufacture the food the tree needs out of the water and minerals taken in from the soil by the roots, and the carbon dioxide "breathed in" from the air by the leaves. Trees differ from people, therefore, in being able to make their own food. People are completely dependent, either directly or indirectly, on green plants for all the food that they eat. Can you explain why?

These boys and girls from Miss Peterson's class are studying twigs in winter condition.

### Twigs in winter condition

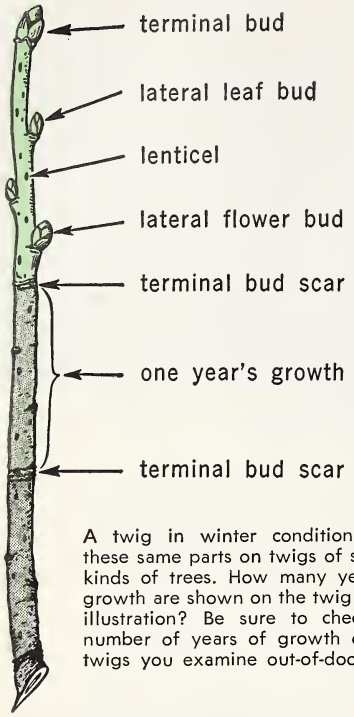
Have you ever wondered why, after a few hot days in spring, the trees suddenly burst into leaf? Do the leaves develop overnight, or were they formed the previous summer? You can find the answers to these questions by performing the exercise outlined below.

#### SOMETHING TO DO

Study a twig of poplar or maple in winter condition. This may be done at any time during the late fall, winter, or early spring.

Find a bud at the end of the twig. This is called a *terminal bud.*

Observe that there are buds along the sides of the stem. They are called *lateral buds.*




A twig in winter condition. Find these same parts on twigs of several kinds of trees. How many years of growth are shown on the twig in this illustration? Be sure to check the number of years of growth on the twigs you examine out-of-doors.

With a sharp knife, make a lengthwise cut through a terminal bud. What do you find inside? Does it contain many small leaves? A terminal bud is fitted to increase the length of the branch or the twig.

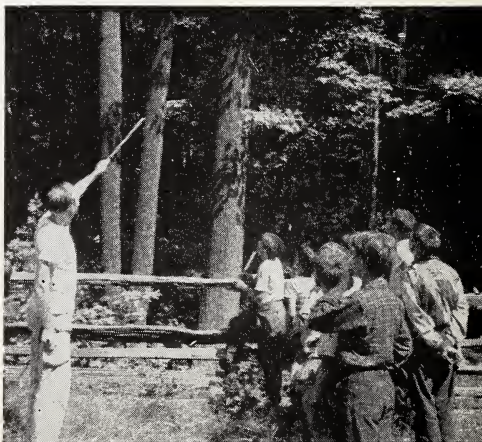
Next, cut open several lateral buds and examine them. Some of them are *leaf buds.* In spring they will grow into new twigs with leaves. Find others that contain flower-like parts; they are *flower buds* and produce only flowers. They open early in spring before the leaves come out. Some trees bear lateral buds that contain both leaves and flowers. Such buds are known as *mixed buds.* Draw terminal, leaf, and flower buds.

Look for two kinds of *scars* on the stem: (1) *Ring* or *terminal bud scars,* which are left when the bud scales of the terminal bud fall off. Count the number of terminal bud scars on your twig. This determines the age of the twig in years. Why? (2) *Heart-shaped scars,* which are left when the petioles or leaf stalks of the previous year's leaves break away from the stem.

Notice the dots or slit-like markings along the stem. These are *lenticels* or breathing pores. The stem takes in oxygen through these small openings to use in the process of respiration.

From your observations of the woody twig in winter condition, you will understand that the flowers and the leaves that suddenly appear on trees in spring were formed the previous summer. They passed the winter in well-protected buds. A short spell of hot, sunny weather is all that is required to cause the buds to burst open.

This class is enjoying a field trip that they have made in order to study trees and to learn to know them where they grow. (Ontario Department of Planning and Development photo)



### How to know trees

In order fully to appreciate the trees in your locality, you should try very hard to get to know them as individuals. The only satisfactory way to do this is to go out-of-doors where the trees are growing and study them first-hand.

You can learn to recognize the different kinds of trees by making accurate observations and a careful study of the following: (1) flowers, (2) leaves, (3) fruits, (4) bark, (5) general shape and growth.

In summer, the leaves alone provide a sufficient means of identification. In winter, when many trees are bare, you may have to depend upon differences in bark, and general shape and manner of growth of trunk and limbs, to tell one tree from another.

Some of our native trees produce beautiful, sweet-scented blossoms in spring. The choke cherry, shown here, is a good example of such trees. (Department of Northern Affairs and National Resources, Ottawa, photo)

### Trees bloom early

Most boys and girls know that fruit trees such as apples, cherries, peaches, and pears have flowers, and that these flowers are necessary if fruit is to be produced. If you have no fruit trees near your home, perhaps you have been fortunate enough to drive through a fruit district at blossom time and marvel at the grandeur of the orchard trees loaded with fragrant flowers. Or if you live on the Canadian prairies, likely you have seen the choke cherry and Saskatoon bushes in bloom in the bluffs, coulees, and valleys.

Possibly you have never realized that the trees along the street and in the forest, such as maples, poplars, elms, and willows, also have flowers in spring and produce fruit and seeds. As these tree flowers are not showy and are lacking in perfume, they are not as noticeable as those of fruit trees. Most forest trees do not depend on bees and other insects to spread their pollen and thus have no need to have attractive, sweet-scented blossoms. They are pollinated by the wind. Often they lack petals and other colorful organs. Willows, alders, and poplars, for example, produce their flowers in the form of catkins

(see illustrations on pages 304 to 306). You may be surprised that the catkins of the pussy willow are flowers. The stamens and pistils are in different flowers — *staminate* catkins contain only stamens, and *pistillate* catkins contain only pistils.

Another interesting thing about tree flowers is that the staminate and pistillate flowers may be on different trees. If you observe Manitoba maple trees in spring, before the leaves are fully out, you should be able to find the two kinds of flowers and learn first-hand that they occur on separate trees. Indeed, the best way to study tree flowers is to make a special field trip for that purpose in spring when they are in bloom, probably about the first day of May. Nearby woodlots, bluffs, windbreaks, or parks are good places to go to make these observations.

#### SOMETHING TO DO

Make a study of tree flowers in spring before the leaves appear. This could be a school field trip or a home project.

1. Look for flowers on the Manitoba maple, sugar maple, elm, poplar, willow, alder, and other varieties of trees. You may not yet know some of these trees, in which case you might gather a few flowers of each kind to take back to school for identification. The illustrations in this book should help you to identify them.

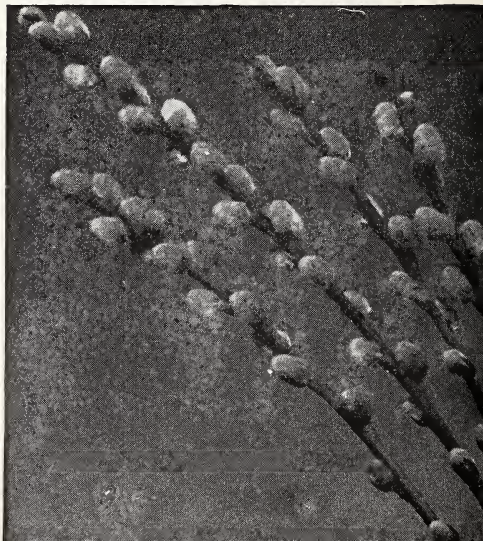
NOTE. — Do not be content to study flowers only from a book — real satisfaction and training in scientific method comes best by examining the actual specimens. These observations should be made first out-of-doors, and followed later by classroom study and further reading.

2. Try to find two kinds of flowers on the willow, or alder. Look for catkins with yellow flowers. These are the staminate flowers — they produce pollen. Find green flowers that may be changing to seed pods. These are the pistillate flowers.

3. Look for staminate and pistillate flowers on poplar trees. If you locate a cottonwood poplar you may find that each pistil of the pistillate catkin is forming a pod containing fluffy seeds; hence the name "cottonwood."

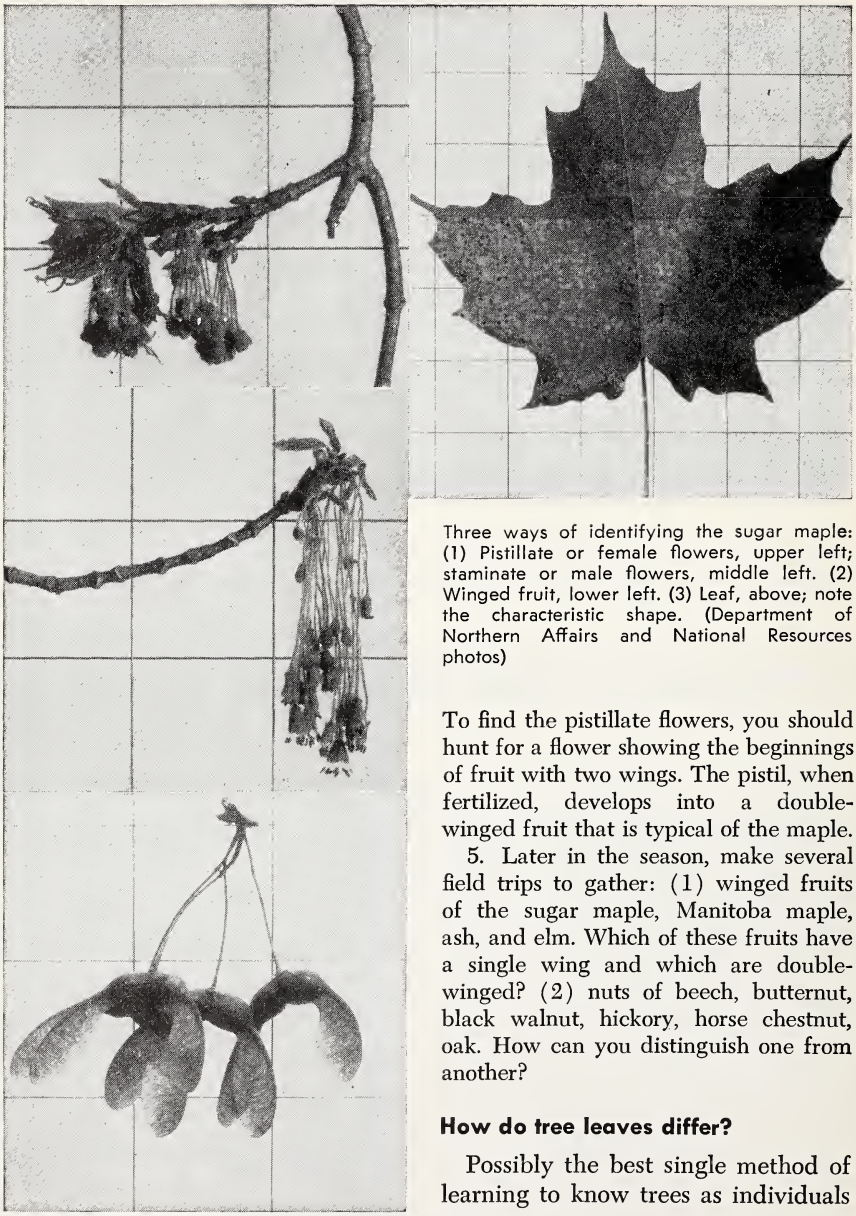
4. Another interesting exercise will be to search for two kinds of Manitoba maple or box elder trees: (1) those bearing staminate flowers, (2) those bearing pistillate flowers. You may have to do quite a little hunting around but it will be worth it. To locate staminate flowers, look for stamens with pollen.

A sign of spring — the pussy willows are out. The "pussies" are catkins or flowers of the willow. (Hugh M. Halliday photo)



Trees can be identified by their flowers. Shown here are two kinds of flowers and fruit of aspen poplar. Left: Catkins containing staminate flowers. Right: Pistillate catkins. Middle: Capsules or fruit containing seeds. (Department of Northern Affairs and National Resources photo)

Manitoba maple (box elder). Left top, winter twig; left bottom, compound leaf; centre top, pistil flowers; centre bottom, stamen flowers; right top, winged fruit; right bottom, bark. (Forestry Branch, Department of Northern Affairs and National Resources photos)



Three ways of identifying the sugar maple: (1) Pistillate or female flowers, upper left; staminate or male flowers, middle left. (2) Winged fruit, lower left. (3) Leaf, above; note the characteristic shape. (Department of Northern Affairs and National Resources photos)

To find the pistillate flowers, you should hunt for a flower showing the beginnings of fruit with two wings. The pistil, when fertilized, develops into a double-winged fruit that is typical of the maple.

5. Later in the season, make several field trips to gather: (1) winged fruits of the sugar maple, Manitoba maple, ash, and elm. Which of these fruits have a single wing and which are double-winged? (2) nuts of beech, butternut, black walnut, hickory, horse chestnut, oak. How can you distinguish one from another?

### How do tree leaves differ?

Possibly the best single method of learning to know trees as individuals

is to make a careful study of their leaves. Each kind of tree has leaves that are peculiar to that tree in shape, margin, veins, and arrangement on the stem. A thorough knowledge of these differences will help you greatly in becoming acquainted with the trees of your community.

**SOMETHING TO DO**

Closely observe the leaves of trees found growing in your yard, along the street or highway, in shelter belts, bluffs, woodlots, parks, or forests.

NOTE. — Be sure you *study trees* and not about trees. You may not find, in your locality, all the trees named or shown in this book. Be sure you study and learn to know the chief varieties of trees that do grow in your part of Canada. It will be necessary to make a number of field trips to learn to know all the trees in your locality.

1. Look for two large classes of trees: (1) Trees with broad leaves, (2) Trees with needle- or scale-leaves.

2. Observe the general shape and growth of the two classes of trees. Which class has trees with branches spreading out in the form of a ball or an umbrella? Which class includes some species that grow in the shape of a cone?

3. (*a*) Look for fruits on the broad-leaved trees. Depending on the season, you may find winged fruits on maples and ash, nuts on the beech and butternut, and acorns on the oak.

(*b*) Look for cones on the needle-leaved trees.

Trees can often be identified by their general shape. The umbrella-shaped tree (centre) is an elm.

NOTE. — The winged fruits, nuts, and cones contain seeds which, under favorable conditions, will grow into trees similar to those on which they grew.

(*c*) Collect samples of these fruits for later study.

4. Next study more closely the broad-leaved trees. (*a*) Find some, such as the elm (see illustration above), the poplar, the sugar maple, the apple, the oak, the choke cherry, the birch, and the willow, which bear *simple* leaves; that is, the blade of the leaf is all in one part (see bottom of page 308).

(*b*) Find other trees such as the Manitoba maple, ash, mountain ash, locust, butternut, sumac, and horse chestnut which bear *compound* leaves, that is, leaves having a blade composed of a number of parts called *leaflets* (see illustration at bottom of page 308).

(*c*) Gather samples of simple leaves and compound leaves for further study and identification.

5. Examine the *simple* leaves from different trees. Often leaves (and the

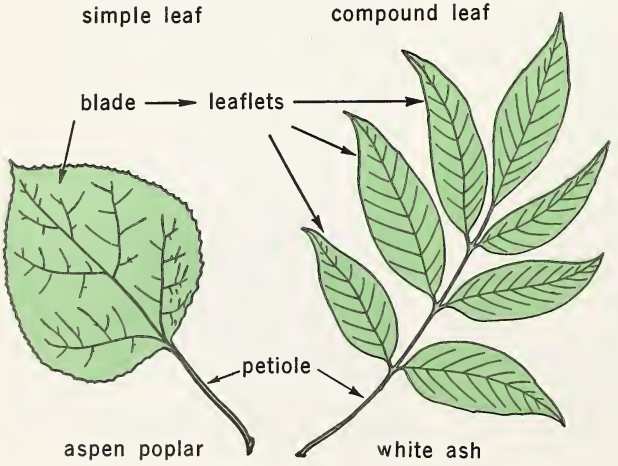
Trees can be identified in winter by their bark. Left: Bark of aspen poplar. Centre: Bark of white elm. Right: Bark of green ash. What differences do you note in the bark of these three trees? (Department of Northern Affairs and National Resources, Ottawa, photos)

trees from which they come) can be identified by the general shape and the margin of the leaf. Find one or more tree leaves with: (1) toothed margin (elm, beech); (2) lobed margin (oak); (3) deeply-cut margin (cut-leaved birch). Has any leaf a smooth margin?

6. Observe the number of leaflets, shape, general texture, and margins of the *compound* leaves of trees that you have collected. Learn to distinguish: (1) the Manitoba maple and the ash leaves; (2) the mountain ash and the locust; (3) the horse chestnut and the sumac.

7. Examine the needle-like leaves of the evergreen trees you have found in the park or woodlot. Look for trees: (1) where the needles are separate, that is, occur singly (spruce, hemlock, fir); (2) where the needles occur in bunches (pine); (3) where the leaves are tiny overlapping green scales (cedar).

8. On evergreen trees where the needles occur *singly,* look for trees that have: (1) sharp-pointed, four-sided needles, which grow all around the stem like the bristles on a bottle brush (white spruce); (2) flat, short needles, whitish on the underside, growing in two rows along the branch giving a flat appearance, possibly tiny cones growing at the tips of the branches (hemlock); (3) larger and thinner needles than




Find other examples of simple and of compound leaves in your locality.

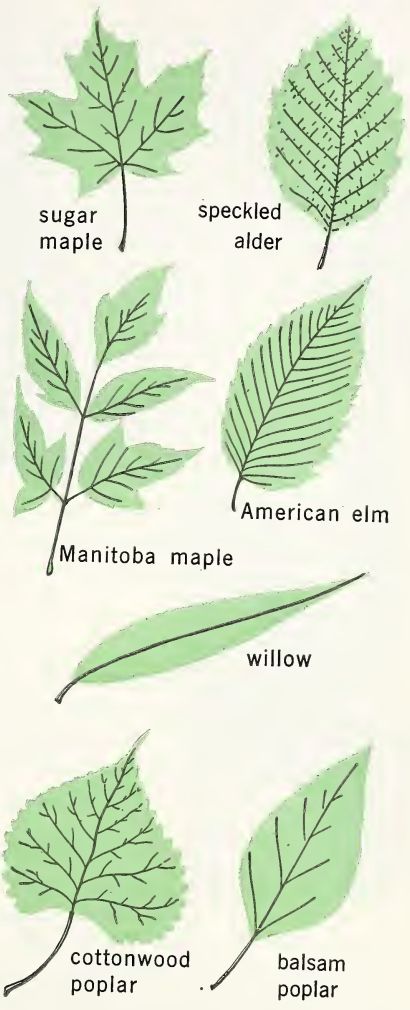
hemlock, growing out along the sides of the branch (balsam fir). (See illustration on page 325.)

9. On evergreen trees on which the needles occur in *bunches,* look for the following members of the pine family: (1) white pine — bunches of five needles; (2) yellow pine — bunches of three needles; (3) jack pine — bunches of two needles about one and one-half inches long; (4) red pine — bunches of two needles about five inches long; (5) Scotch pine — bunches of two needles about two to three inches long.

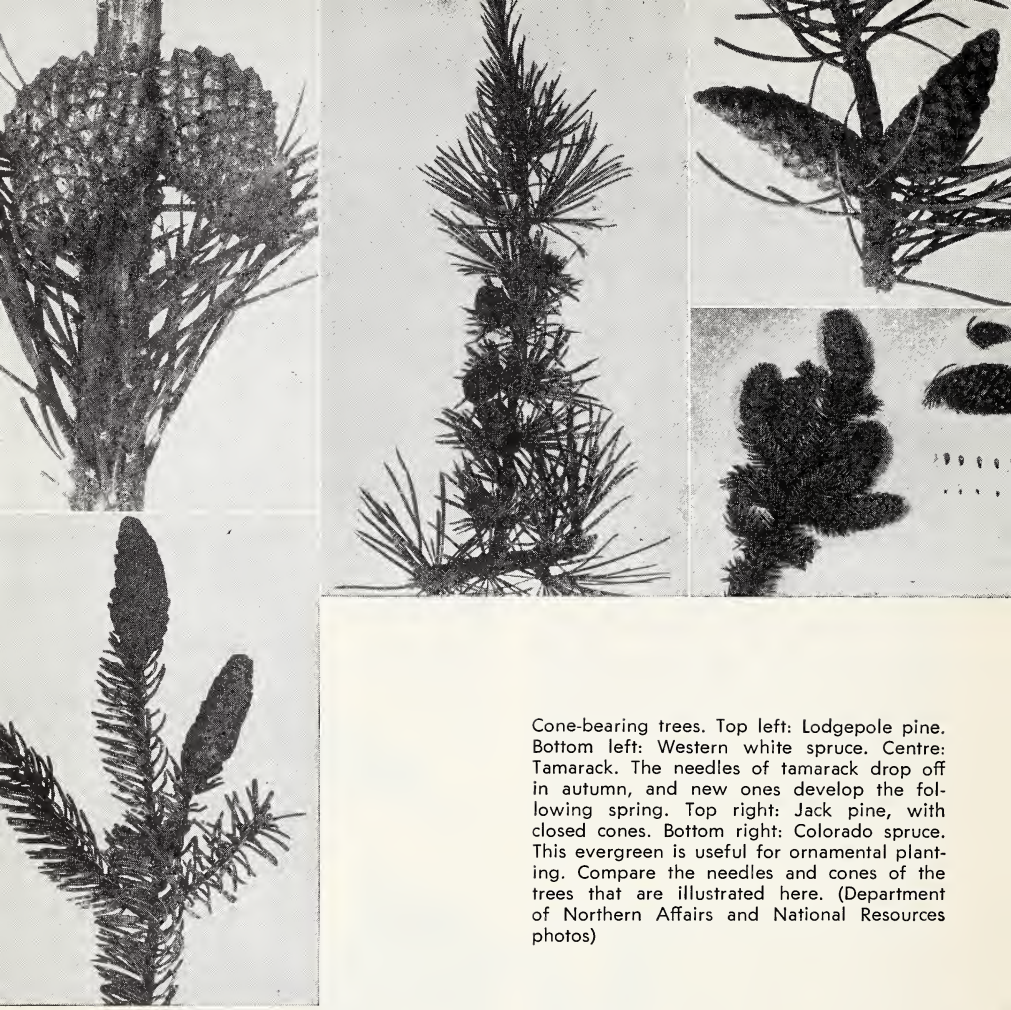
Assuming that you have carried out carefully and thoroughly the observations and investigations outlined above, you will have learned that the leaves of different species of trees differ greatly and that these differences are used to classify trees into various groups or classes. Because of differences in conditions such as soil, temperature, and rainfall, the kinds of trees to be found in the various provinces of Canada differ widely.

Trees are commonly classified into two large groups on the basis of the structure of their leaves: (1) *broad-leaved* trees which include the elm, the maple, the poplar, the willow, the oak, the choke cherry, and many others; (2) *needle-* or *scale-leaved* trees such as the spruce, the pine, the hemlock, the fir, the cedar, the tamarack, and the juniper.

Broad-leaved trees shed their leaves in the fall, for which reason they also are known as *deciduous* trees. The only native broad-leaved tree in Canada that does not shed its leaves in the autumn is the arbutus of the Pacific Coast.




Examples of deciduous leaves. Which of them can you find in your part of Canada?



Cone-bearing trees. Top left: Lodgepole pine. Bottom left: Western white spruce. Centre: Tamarack. The needles of tamarack drop off in autumn, and new ones develop the following spring. Top right: Jack pine, with closed cones. Bottom right: Colorado spruce. This evergreen is useful for ornamental planting. Compare the needles and cones of the trees that are illustrated here. (Department of Northern Affairs and National Resources photos)

Needle-leaved trees are called *evergreens* because the great majority of them do not drop all their leaves in the fall but remain green all through the year. Sometimes these trees also are called *conifers*, because their seeds are produced in "cones." One needle-leaved tree, the tamarack, sheds its leaves each fall.

Broad-leaved, or deciduous, trees, as a group, are known as *hardwoods*, while the needle-leaved, or evergreen, trees include the *softwoods*. When you perform the experiment outlined on pages 316 and 317 you will learn the characteristics of hardwood and of softwood lumber and of the uses of each kind of lumber in our houses.

#### TEST YOUR KNOWLEDGE AND UNDERSTANDING

1. Trees and people have much in common. Explain.
2. Draw a twig of a maple or of a poplar tree as it appears in winter. State the purpose of each part shown.
3. In order to recognize or identify different kinds of trees, what are some of the things we need to know about them?
4. Flowers of fruit trees are showy and fragrant, while flowers of most forest trees are lacking in color and perfume. Why does this difference exist?
5. Name the two kinds of flowers commonly found on poplars and maples and state the purpose of each.
6. Make labelled drawings of tree leaves to illustrate: (1) a simple leaf, (2) a compound leaf.
7. Why are broad-leaved trees called deciduous trees?
8. Needle- or scale-leaved trees as a group are known as *evergreens, conifers,* or *softwoods.* Which of these names do you think is the most suitable? Why?
9. Make two lists of the trees you have seen growing in your locality. In one list put the names of the broad-leaved trees and in the other the names of the needle- or scale-leaved trees.

## PLANTING TREES

It has been said that "when we plant a tree we make our planet a more wholesome and happier dwelling-place, not only for ourselves but also for those who come after us." Trees planted in the home or school grounds are both useful and ornamental. They not only beautify the surroundings, but also provide shelter from the scorching sun of summer and the drifting snow and bitter winds of winter. Suitable trees can be successfully grown on any school ground or farm site by following recommended methods. A few trees and shrubs planted each year, in accordance with a definite plan, will accomplish wonders in a few years.

Arbor Day is a day set apart for the planting of trees and otherwise improving the appearance of your school yard. *Plant a tree this year on Arbor Day.*

#### SOMETHING TO DO

1. In some schools, the members of the graduating class follow the excellent custom of planting a tree on Arbor Day. This tree is known always as *their* tree. If you are preparing to graduate, make plans with your classmates to plant a tree in your school grounds this spring. Plan a program for the event.
2. Read the following poem which was written by Warren P. Landers and which is published by kind permission of *Advance* magazine.

Planting a tree in the back yard. How is each boy assisting? What steps in tree planting have they taken up to the time of this photograph? What remains to be done? Check with the illustration on page 314. (M. Kesterton photo)

### When We Plant a Tree

What do we plant when we plant a tree?
We plant a home that is to be —
A ship to sail across the sea —
A desk, a chair, a book maybe —
These we plant when we plant a tree.

What do we plant when we plant a tree?
Beauty and joy for all who see —
A home for birds to bide a wee —
Grateful shade for you and me —
These we plant when we plant a tree.

(*a*) What uses of trees are mentioned in the poem?

(*b*) Name some uses of forest trees that are not mentioned.

(*c*) Using the above verses as patterns, compose a verse to include some of the values of trees you have listed in your answers to (*b*).

## How to establish a tree

Plant to a Plan.—School grounds should be laid out according to a definite plan that can be worked out over a period of years. In drawing up a plan, careful consideration should be given particularly to the placing of trees, since they are likely to grow for a long time and cannot readily be moved. If no such plan has been made for the improvement of your school grounds, ask a gardener to help you to draw a sketch showing in a general way the best location for a shelter belt, individual trees, shrubbery, and flower gardens. Keep the plan carefully at the school, and use it from year to year as you plant trees. Reserve the ground in front of the school building for flowerbeds and shrubbery, and plant your trees at the sides or corners of the building or in positions where they will screen the other buildings. Arrange most of the trees in natural clumps, but plan to have a few single trees in desirable locations.

The safest guide in choosing trees for your school yard is to use those that are fairly common in your district. As you have already learned, in Western Canada common trees include: *poplar, Manitoba maple, elm, green ash,* and *willow.* These are hardy and easily grown. *Scotch pine* and *blue spruce* are expensive to buy and require special care in planting, but they are well worth the extra expenditure. In Eastern Canada, suitable trees are: *sugar maple, silver maple, white oak, red oak, Lombardy poplar, silver birch, American elm, Scotch pine, white pine, red pine, white spruce, Norway spruce, white cedar,* and *red cedar* or *juniper.*

Where To Get Trees. — Trees for school planting in Western Canada

may be obtained from three main sources: (1) the Dominion Forestry Service, (2) woods, bluffs, and valleys, (3) commercial nurseries.

The Dominion Forestry nursery stations at Indian Head and Sutherland, Saskatchewan, will supply trees for windbreaks, *free of charge,* to any farmer or school in the three Prairie Provinces, on condition that the soil in which the trees are to be planted is properly prepared, and that the trees are well cared for after planting. A similar service for Ontario schools is provided by the Department of Lands and Forests, Parliament Buildings, Toronto.

Note. — For further information regarding tree planting and free distribution of trees, the teacher or a school board official should write either to the Chief of Tree Planting Division, Dominion Forestry Nursery Station, Indian Head, Saskatchewan, or to the Department of Lands and Forests, Parliament Buildings, Toronto, Ontario.

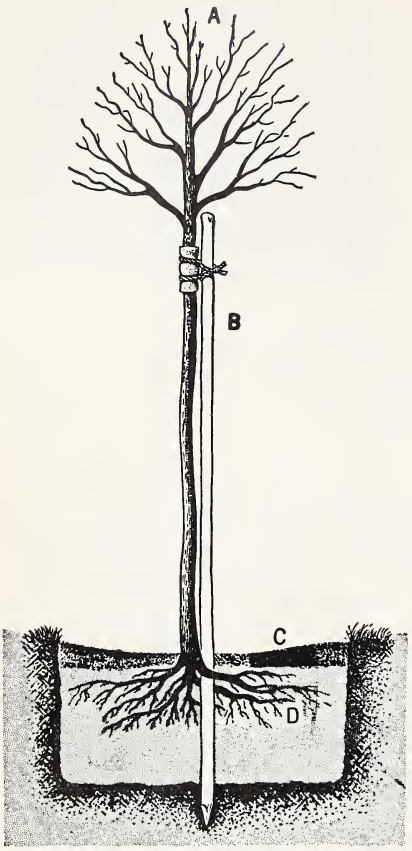
For transplanting from woods, bluffs, or valleys, choose small trees that you can dig up and transport without cutting away too much of the root system. A maple or a poplar four or five feet high is much more likely to grow than one of twice that height. When you have dug up a tree, leave some soil on the roots to protect them from the air. Wrap the roots in old bags, keep them moist, and put them into the ground again as soon as possible.

Care before Planting. — The best time to plant trees is early spring, soon after the frost is out of the ground and before active growth has commenced. Arbor Day, the first Friday in May, usually is the ideal time. *Roots of evergreens must not be exposed to the sun and wind for even one minute.* If they become dry, they will likely die.

The best plan is to have everything in readiness when your trees arrive and to plant them at once.

Careful Preparation Is Important. — Dig a wide, deep hole and place some good topsoil in the bottom of it. The hole should be deep enough to allow the tree to be planted at the same depth as or not more than two inches deeper than it was in its original location, as shown by the marks on the trunk. The hole should be as large at the bottom as at the top and should be wide enough to permit the roots of the tree to spread out to their full length, with several inches to spare.

How To Plant Your Tree. — Heap up, in the form of a cone, the topsoil that you have placed in the bottom of the hole. Stand the tree on the cone, and spread the roots out in their natural, nearly horizontal position; see that none of the roots are bent under or cramped in any way. Cover the roots with very fine topsoil, and raise and lower the trunk of the tree an inch or two a number of times, to work the soil in around the roots. Add more soil, and again work it in around the roots. When the roots have been covered to a depth of five or six inches, using your heel, tramp the




The above drawing illustrates the proper method of planting a tree. A, the top reduced; B, the support; C, a layer of loose, dry soil; D, the roots well spread out and surrounded by a good topsoil, firmly tramped.

soil firmly, if it is not wet. (Work with a classmate, one of you holding the tree erect while the other shovels in the soil and tramps it down. See illustration on page 312.) Continue filling in and tramping firmly until the soil is within three or four inches of the top of the hole. Fill the hole with water. When the water has disappeared, place two or three inches of dry, loose soil over the surface. A small depression should be left to act as a catch-basin for more water. Make the area around the tree neat and tidy.

### Caring for trees

Until the roots of a tree have become firmly established in their new abode, the tree should be supported by means of a long, stout stake, which should be placed in the hole at the time of planting. Wrap the trunk of the tree with cloth, and then fasten it securely to the stake with strong cord (see diagram at left).

Trees should be fenced or otherwise protected from injury from livestock. If it is necessary to protect trees from being girdled by rabbits, place stove piping around the trunks, or wrap the trunk in tarpaper or magazines.

Trees, except evergreens, should be pruned immediately after they are planted, so that the top will balance the reduced root system. Cut off some of the lower branches and most of the previous year's growth of the remaining side branches, leaving the central, most vigorous and straightest branch or leader to grow into the main trunk of the tree. When removing an entire branch, make the cut close to the trunk. If the cut surface is large, paint it or cover it with tar to protect the tree from disease. Con-

tinue pruning each year until the lowest branches are about six feet from the ground. When trees are intended for a shelter belt, a dense growth being the aim, they should be pruned only at the time of planting.

Plenty of moisture is essential to all newly planted trees. Water your tree well every few weeks the first season and, if possible, during all dry years. Keep the soil around it well cultivated and free from grass and weeds. A mulch of compost, leaves, or straw helps to reduce evaporation and protects surface roots from the sun. Watch your trees for the appearance of injurious insects and plant diseases.

#### SOMETHING TO DO

1. Write for a bulletin dealing with the control of insects that attack shade trees. One may be secured, free of charge, from the Forestry Branch Nursery Stations at Indian Head or Sutherland, Saskatchewan. In Alberta, these bulletins may be obtained from the Science Service Branch of the Federal Department of Agriculture, in Calgary, or from your nearest agricultural representative.

2. If you plan to plant a shelter belt at home, write to the Director of Forestry, Department of Northern Affairs and National Resources, Ottawa, for information about suitable varieties for your area and proper methods of planting.

#### TEST YOUR KNOWLEDGE AND UNDERSTANDING

Discuss tree planting in your locality under the following headings: (1) Preparation of the soil for shelter belts and for single trees, (2) Suitable varieties, (3) Where to get trees, (4) Care of trees before planting, (5) How to plant trees, (6) Care after planting.

Talk over, too, how to restore to good growth and health trees that have been neglected. If such trees exist at your school, plan to improve them. Consider such features as pruning, cultivation of soil, controlling insects and disease. Plan, also, to replace dead trees.

## WOOD, OUR MOST USEFUL BUILDING MATERIAL

In building houses, a great many different materials are used, such as wood, stone, concrete, bricks, mortar, plaster, glass, and a number of metals. Before building a house, the builder learns as much as possible about each material, so that he can be sure of having a warm, attractive, durable house. Some materials, such as insulation, are used chiefly to control heat in the house. Others are selected because they are inexpensive, strong, beautiful, or easy to assemble. Each material has some advantages and some disadvantages.

Wood is one of the most extensively used building materials. For what parts of a house is wood used? Which trees are most commonly used in building and for what is each used?

**SOMETHING TO DO**

Visit houses that are being built in your neighborhood, to find out about the uses of wood. Ask the workmen if you may go into the houses. Be very careful as you walk through them. Ask permission before you handle any materials. *Do not go into houses under construction when the workmen are away.*

Many problems or questions will come to your mind as you look around a new house. As a young scientist, you should remember to make very careful observations to help you find answers. The workmen may give you much information, if they see that you are thinking for yourself. You will find answers to your questions about wood as you read on in this section.

## Wood has many uses as a building material

Wood, in the form of lumber, is our most useful building material. What parts of your house are wood? If you live in a frame house, most of the parts above the ground are made of wood. In brick, stucco, and stone houses, the framework of the inner walls, ceiling, and roof, as well as the floors and trim, are lumber. It would be difficult and very expensive to build a house without wood. Why is wood so useful as a building material?

You already know some of the advantages of wood. Nails can be driven into it, and it can be cut easily into suitable shapes and sizes. Wood is much lighter than brick and concrete. Why is this an advantage in the walls, ceilings, roof, and doors of your house? Wood is less costly than most other building materials. In some parts of a house, such as in door panels and floors, its beauty adds to the attractiveness of the building.

What are some of the disadvantages of wood as a building material? In case of fire, what materials would be safer than wood? What happens to a piece of wood that is left outside without protection from rain? Why is it necessary to paint wood? Wood is seldom as strong or durable as brick, concrete, and stone.

## What kinds of wood are used in building houses?

Tom Grant and several of his friends volunteered to visit a carpenter and a lumber-yard to find out what trees are used in making the lumber for houses. The next day they brought to school several small pieces of lumber to use in activities that would help the class in distinguishing different kinds of lumber.

**SOMETHING TO DO**

Get some samples of the lumber used in building the frame of a house. Examine it very carefully, to see if the *fibres* are coarse and fairly loose, or very fine and tightly packed together. Scratch a nail across the wood. Did it loosen some of the fibres? Can a nail be pounded into it easily?

Tom told the class that the trees most commonly used for building the frames of houses are pine, spruce, fir, and hemlock. These trees all have needles instead of broad leaves and

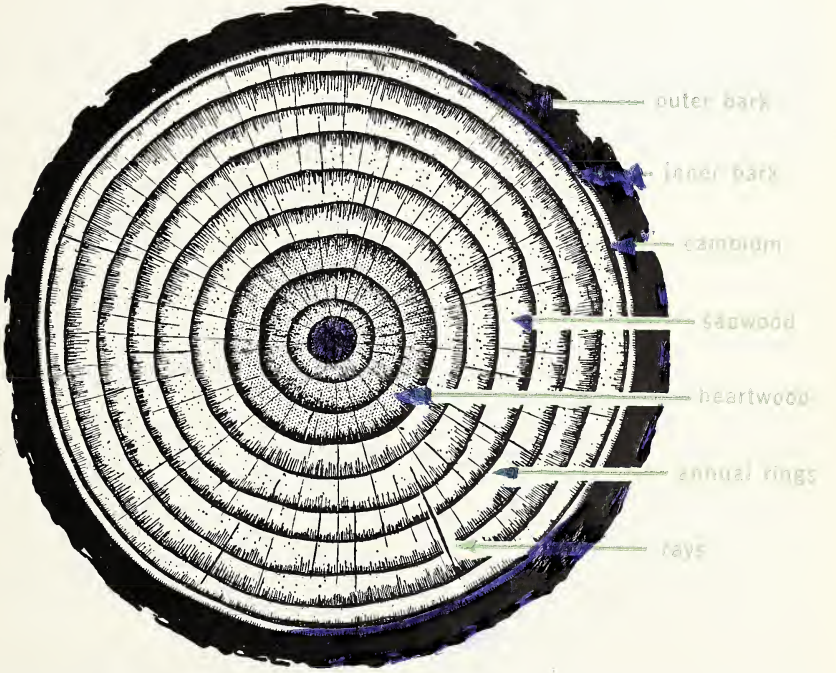
are called *softwood* trees. Their wood is made up of large, loosely-packed fibres. For this reason, nails can be driven easily into the wood without splitting it.

**SOMETHING TO DO**

Obtain several pieces of board used in the floors and woodwork of a house. Examine the size of the fibres. Test these boards for hardness by scratching them and pounding nails into them.

When the class had tested these boards, several pupils knew that this wood was called *hardwood.* The hardwood trees from which we get the lumber for floors, doors, and some other woodwork, are broad-leaved varieties such as the red oak, white oak, sugar maple, and yellow birch. The wood of some broad-leaved trees, such as the aspen and the basswood is not as hard as oak. However, we give the name *hardwoods* to all broad-leaved trees.

Apply what you have learned in your activities with hardwood lumber to explain the advantages of using




This diagram of the end of a log shows the layers of wood that have been added each year. After you have read pages 318 and 319, you will be able to answer the following questions: How long did it take this tree to grow? How many rings of heartwood and of sapwood are there?

The wood of a tree is made up of millions of tiny *cells* or *fibres*. This photograph shows cells of the white birch tree, magnified twelve times. The cells have been separated from each other by soaking a piece of wood in an acid. As you can see, most wood cells are shaped like tiny tubes with closed, pointed ends. The millions of cells in the wood of a tree are packed closely together, and extend lengthwise up the trunk of the tree. When you look at the cells in the end of a log they appear round because you are looking at them in cross-section. (Forest Products Laboratories photo)

oak, maple, or birch boards for making floors.

### From tree to board

Ronald Shaw's father took several of the pupils to visit a sawmill. They reported some of their observations and experiences to the class.

After a tree has been cut down and sawn into suitable lengths, the logs are taken to the sawmill to be cut into boards. If required, this rough lumber is passed through machines which *dress* it, or make it smooth. The lumber should be dried before it is used, or it is likely to *warp* (bend and twist) after it has been nailed in place in a house. The lumber may be dried quickly in a heated *kiln*, or it may be piled carefully outside and allowed to dry or *season* for several months.

### What makes the grain in a board?

When the pupils were studying hardwood boards, several of them observed a beautiful pattern of light and dark lines in the wood. They also found this *grain* in the unpainted wood of the door and the furniture.

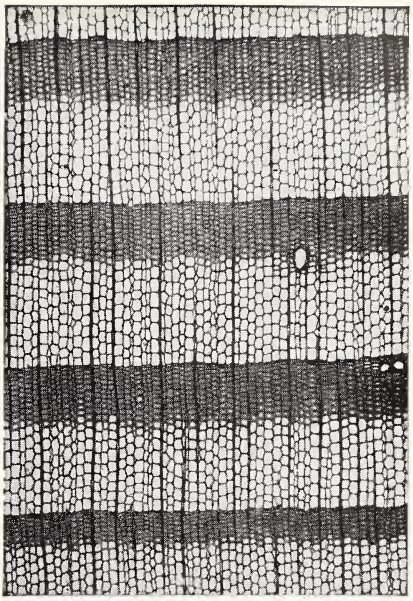
We can learn to identify kinds of wood by the grain, which is different in each kind of wood. The beautiful grain of oak makes it a popular wood for furniture.

Before we can understand why wood has a grain, we need to be able to recognize the parts of a log and understand how a tree grows.

#### SOMETHING TO DO

1. Examine several boards, as well as the doors, the trim, and the furniture in your home and classroom, and study the grain in the wood.
2. Cut several sections from the end of a log and bring them to school. Blocks of wood will do. If you make the ends smooth with a plane, the parts will be seen more clearly. Use the drawing on page 317 as a reference in finding the parts of the tree trunk from which the sections were cut.

Inside the bark on a log is a layer of *cells* called the *cambium* layer. This is the growing part of a tree and each year it produces a new ring of



The picture at the right is a magnified photograph of the outlined section of the western birch tree illustrated in the diagram above. The photograph shows the tree's annual rings. As you study the picture, notice the differences between the large, light-colored, thin-walled cells of spring wood, and the smaller, dark, thick-walled cells of summer wood. How old was the tree shown above? How many years of growth are shown in the photograph? (Forest Products Laboratories photo)

wood just under the bark. You can tell the age of a tree by counting the number of these *annual rings.*

Are all the annual rings of the log of equal width? In a warm, moist year a tree grows rapidly, and makes a broad annual ring. Find a year when the tree grew rapidly, and one when the tree grew only a very little. What might have caused the tree to grow only a small amount during one year?

Notice that the annual rings of wood near the centre of the log are darker in color than those near the bark. For a few years after each annual ring is formed, it carries sap between the roots and leaves. These layers of *sapwood* are usually light in color. When the wood loses its ability to carry sap, it becomes darker, and is called *heartwood.*

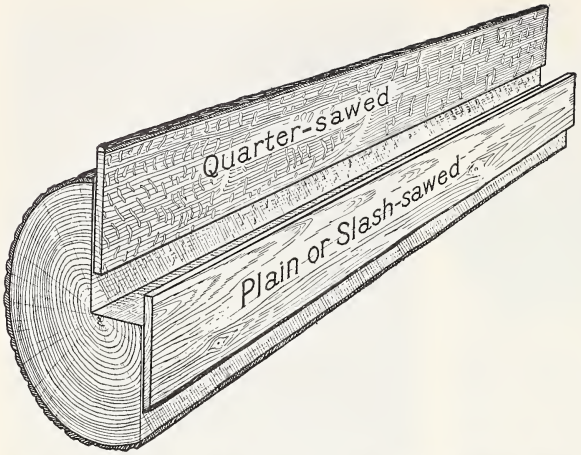
**SOMETHING TO DO**

1. Count the number of annual rings of sapwood and heartwood in the log you are studying.

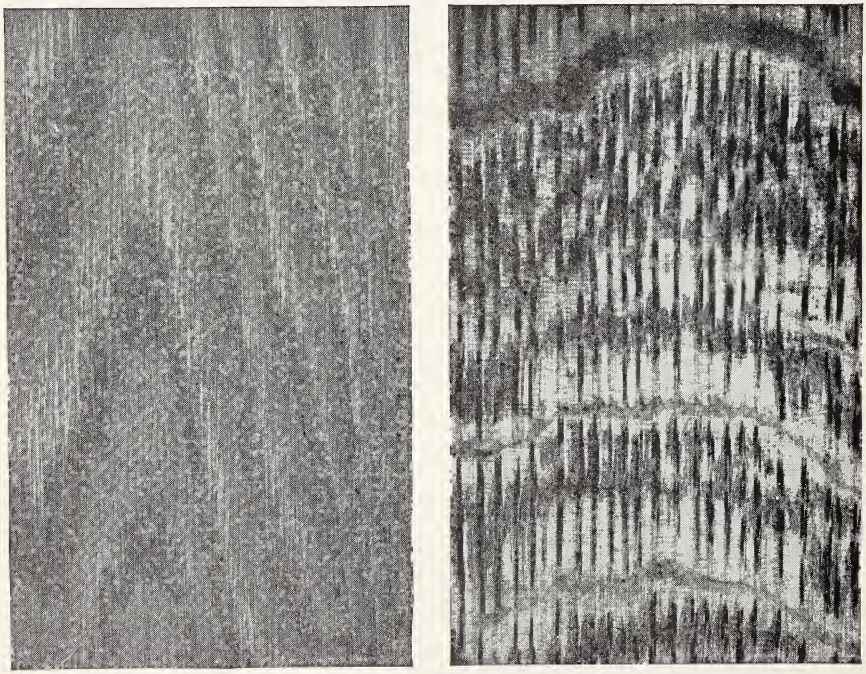
2. Examine the boards in an oak floor. Find the ones that were cut from sapwood and those that were cut from darker heartwood.

3. Find the *rays* which run from the cambium layer in toward the centre of the log. The rays carry food and water from one annual ring to another.

4. Examine the annual rings very closely. If possible, use a magnifying glass. You may see that each annual ring is made up of a light layer and a dark one. What causes these two layers in each annual ring?




This drawing illustrates how plain-sawed and quarter-sawed oak boards are cut from a log. (United States Forest Service photo)



Photographs of the grain of plain-sawed oak (left) and quarter-sawed oak. (Forest Products Laboratories photos)

In spring, in order to produce a new crop of leaves, a tree must quickly raise vast quantities of food-laden sap to the branches and twigs. For this reason, the cambium layer produces wood with large tubes to transport the sap upward. At this time the tree grows rapidly, forming large cells with thin walls. These cells and the large tubes for conducting sap give the spring wood a light color. In summer, when growth and circulation become slower, a layer of smaller cells with thicker walls is formed, giving a darker color to the wood. Although this change is gradual, the difference between the dark wood of one summer and the light-colored growth of the following spring makes a line where they join. This is the annual ring.

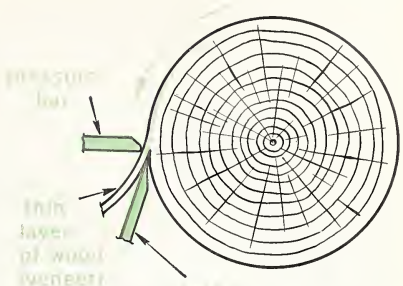
Examine a log to find the light layer and dark layer which form each year's growth. The grain in a board is formed when these light and dark layers appear on the wood's surface.

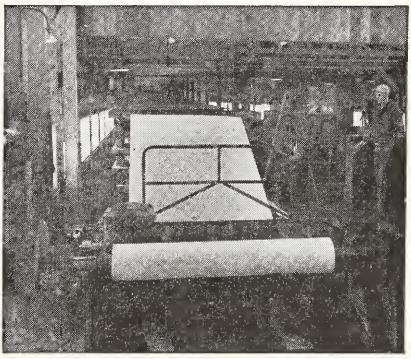
**SOMETHING TO DO**

1. Study the two lower pictures on page 320 showing the difference in grain of plain-sawed and of quarter-sawed lumber. The marks crossing the grain of quarter-sawed lumber are the rays. Why do we say that this log is quarter-sawed?

2. If possible, bring to class two boards cut from the same log, one plain-sawed, the other quarter-sawed. Find the light-colored spring layers and the darker summer layers.

3. Examine boards in your floors and furniture, to find examples of grains formed by plain-sawing and quarter-sawing.





Top: A lathe peels thin layers of wood from a log. (Forest Products Laboratories photo) Bottom: The veneer being cut from the log in the foreground will be made into plywood. (British Columbia Forest Products Ltd. photo)

## How is plywood made?

Modern science has given us a new form of board, plywood, which is bought in large pieces that are useful in making doors, cupboards, wall panels, and furniture.

**SOMETHING TO DO**

Bring to school several pieces of plywood. Notice that they are made of thin layers of wood glued together. Examine the end grain in each layer. You will see

that alternate layers are turned in opposite directions. This arrangement strengthens the wood and helps to keep it from warping.

The thin layers of which plywood is made are first peeled from a log and then glued together and dried under great pressure. When some kinds of plywood are left outside without being protected with paint, water dissolves the glue, allowing the layers to break apart.

**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

1. List four advantages that wood has over most other building materials.
2. Name three trees that provide us with hardwood lumber.
3. Why is red oak lumber better than white pine for making floors?
4. Make a drawing of the cross-section of a tree eight years old. Show two years' growth of heartwood. Label carefully the following parts: cambium, annual rings, heartwood, sapwood, rays.
5. Explain why a year's growth in a tree is made up of a light-colored layer and a dark layer of wood.
6. Describe the arrangement of the layers in plywood. How does this arrangement improve plywood?
7. What makes the grain in a board? Describe a piece of beautifully grained wood that you have examined recently.

The carpenter, like the scientist, must work with great accuracy. This carpenter is using a spirit level to make sure that the side of the window frame is plumb, or vertical. Examine a level to see how it is able to show whether a wall is plumb and whether a floor is level. Notice that the basic structure of this building is wood. (Vern Kent photo)

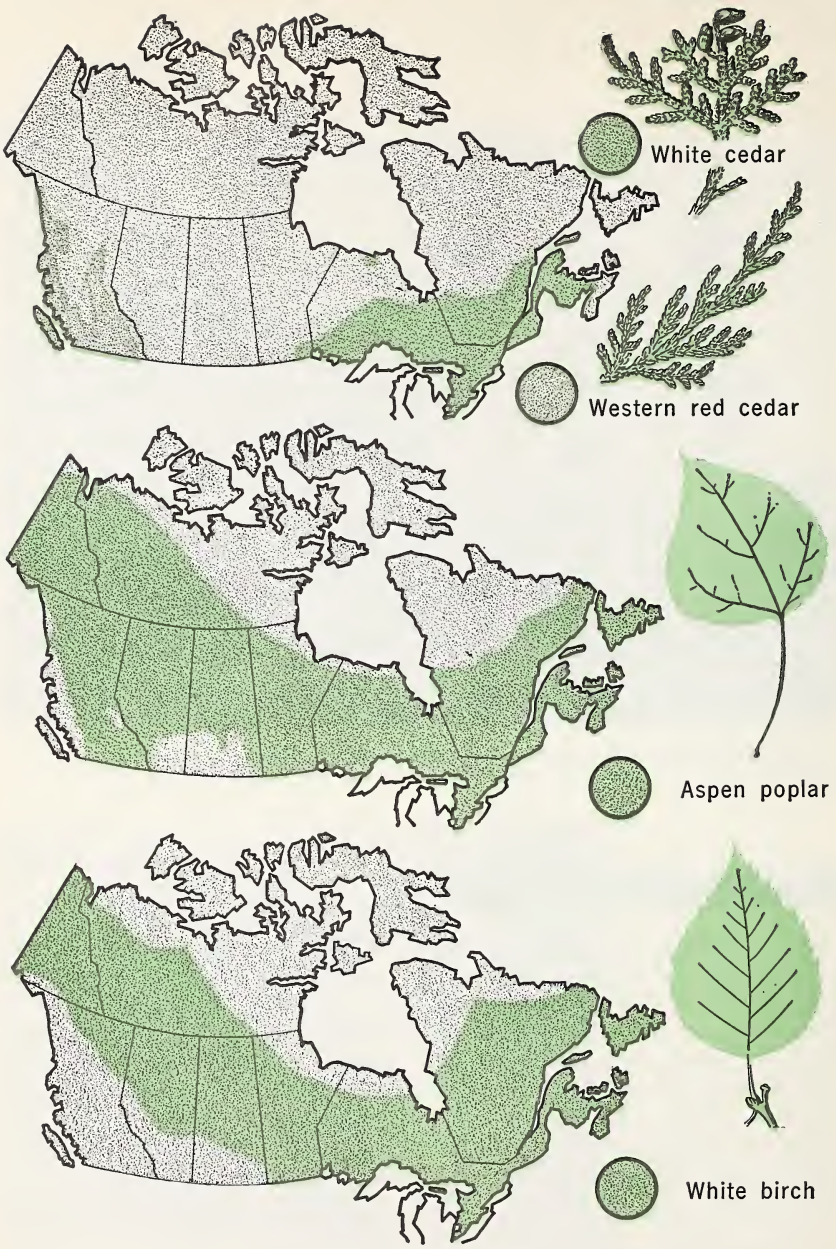
This attractive frame house is built of white pine lumber. What purpose is served by paint in addition to making a house look attractive? (Forest Products Laboratories photo)

## CANADA'S VALUABLE FORESTS

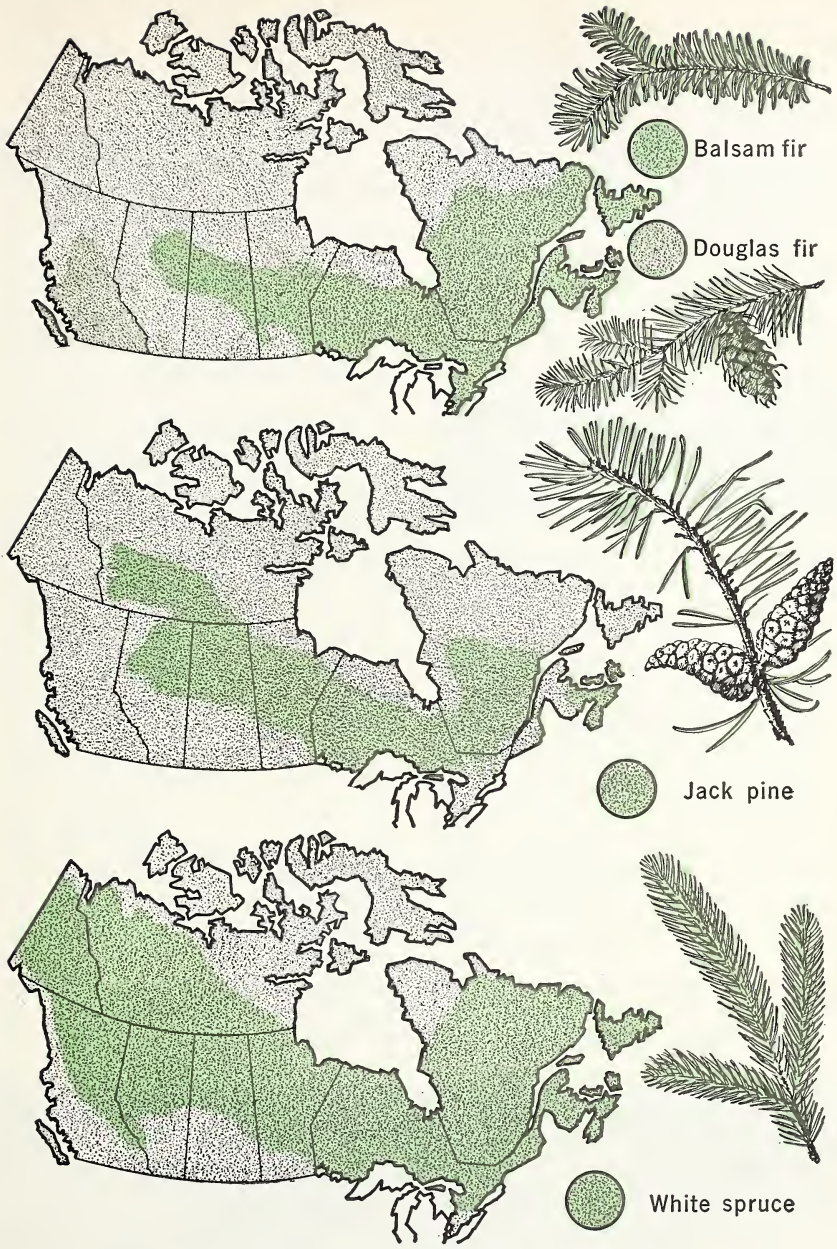
Study the maps shown on pages 324 and 325 to find where some of the main varieties of deciduous and evergreen trees are growing in Canada. To learn about the distribution of other important varieties of trees, consult *Native Trees of Canada,* published by the Dominion Forest Service, Department of Northern Affairs and National Resources, Ottawa.

### Forests are valuable in many ways

Our forests are one of our basic and most valuable natural resources. Forest trees are of inestimable value in a number of ways in their natural state. As you have already learned in Chapter 7, one of the ways in which forests aid us greatly where they stand is in the *control of floods and soil erosion.* Trees, particularly those on hillsides and slopes, prevent a sudden run-off of water in spring or after a heavy rain. Where large areas of sloping land have been cleared of trees, it has been found that running water has washed away the rich topsoil and has cut deep gullies into the




Distribution in Canada of two cedars and two common deciduous trees. Which of these have you seen growing in your locality? Name several deciduous trees that are common in your part of Canada and which are not shown in this illustration.




Distribution in Canada of four common evergreens. Which one is the most widely distributed? Which of them grow in your locality? Name some evergreens not shown here.

terrain. This has led to a loss of soil fertility and has greatly impoverished the land. While the forest is there, the roots keep the soil porous so it can absorb large quantities of water. In addition, the decayed leaves and other decomposed plant material add a great deal of humus to the soil, making it spongy. If you recall your experiments on the water-holding capacity of different kinds of soil materials in Chapter 7, you will remember that a soil rich in humus has the greatest water-holding capacity. Forest soil, therefore, is adapted for soaking up the water from melting snow and from rains, thus preventing sudden heavy run-offs. It is true, also, that the snow in heavily wooded areas melts much more gradually than snow in untreed areas, which is a further aid in preventing spring floods which cause damage to life and property.

Forests supply *protective cover and feeding areas for wildlife.* Large numbers of birds depend on the forest trees for nesting sites and for food. In turn, these birds greatly benefit trees and man by consuming tremendous numbers of harmful insects. Many mammals such as the deer and the fox depend on the forests for protective covering and food. Hunting and trapping of game and fur-bearing animals are pursuits of man that are dependent on the forests.

Canadian forests are very valuable as *recreation areas* for people on vacation. National parks comprising heavily treed forests, colorful lakes, sparkling rivers, towering waterfalls, and rugged mountains have been set aside for the enjoyment of Canadians and of tourists who visit our country. Here, camping, hiking, fishing, boating, and swimming provide healthful recreation for many thousands of people each summer. The shaded forest keeps the streams cool and fresh so that trout and other fish thrive in them. Forests are the natural habitats of many of our most beautiful wild flowers, which are a joy to the nature lovers who visit

Three popular wild flowers. Left: Wild rose, the floral emblem of Alberta. Centre: Trillium, the floral emblem of Ontario. Right: Wild lily, the floral emblem of Saskatchewan. Enjoy wild flowers where they grow and leave them to provide pleasure for others. (Photos by: left, Hugh M. Halliday; centre, Ontario Department of Travel and Publicity; right, Fred S. Robinson)

them. Some of these national playgrounds operate during winter as well, for the benefit of those who are interested in winter sports such as skiing.

*Windbreaks* and *shelter belts* of trees on 65,000 Canadian prairie farms serve several useful purposes. They help to make the home and its surroundings attractive. They provide shade for the farmer, his family, and his livestock, and serve as windbreaks for buildings, garden crops, and farm animals. They attract birds which feed on insects that might do untold harm to crops. They also help to restore fertility to the soil in the form of leaf-mold. Shelter belts check the speed of the wind and so prevent the drifting of both snow and soil. Because they have so many advantages, trees add considerably to the sale value of a farm.

Compare these two farmsteads. In which farm home would you prefer to live? State several reasons in support of your answer.

### Farm woodlots

A farm woodlot that is well stocked with valuable trees is an important asset to any farm. It is the considered opinion of leading authorities in the province of Ontario, for example, that a minimum of 10 to 20 per cent of all farmland should be growing trees. Often it is possible to grow a good crop of trees on hilly, swampy, or sandy land that is of little use for raising the usual farm crops, or for pasture.

Woodlots are of benefit to farmers in a number of ways. From a woodlot, a farmer can obtain fuel to heat his home, timber and lumber for buildings, and posts with which to fence his fields. He can sell logs and fuelwood for ready cash. Woodlots containing a good stand of sugar maples are a source of maple syrup and maple sugar for the farmer's table or for sale. Cash returns from woodlots are especially helpful in years when cultivated crops are a failure.

Because of these and other values referred to on pages 323 and 326, it is very important that farm woodlots be protected and used wisely. Often they are seriously damaged by cattle that are allowed to graze in the woodlots. Cattle feed on the young seedlings and break down the saplings. The wise farmer keeps his woodlot fenced from cattle and other farm livestock. By so doing he protects his farm forest and gives the trees a chance to grow into a paying crop for

A properly-managed farm woodlot. Only mature trees are harvested. Note the young trees that will become the future forest. Cattle are not allowed to pasture in this woodlot. (Ontario Department of Planning and Development photo)

In the photograph above, the woodlot on the right of the fence has been pastured. How is it different from the one on the left of the fence? Explain these differences in terms of conservation. (Ontario Department of Planning and Development photo)

him to harvest from year to year as the trees reach maturity.

### Forest products are widely used

The uses of the products of our forests are very numerous. It has been estimated that trees and tree products are used in about 5000 different ways.

#### SOMETHING TO DO

Before proceeding further with the study of this section, make a list of all the uses of forest trees and tree products that you know. Look around your home, school, farm, garden, street, highway, store, and elsewhere in your environment for suggestions, then compile a list of different uses of wood under such headings as:

(1) Uses of wood in the home.
(2) Uses of wood on the farm.
(3) Uses of wood for transportation.
(4) Uses of wood for communication.
(5) Uses of wood for recreation.

The foregoing exercise should serve to emphasize the importance of forest products in our environment. Below are a few of the very many uses of tree products. How many of these uses did you mention in your list? Did you think of any other uses of lumber that are not given below? (1) *Lumber and timber* for building houses, barns, furniture, boats, boxcars, and packing boxes. (2) *Sporting equipment* such as toboggans, skiis, hockey sticks, tennis racquets, and baseball bats. (3) Wood as a *fuel* for heating homes and other buildings. (4) *Ties* for railroads. (5) *Poles* for telephone, telegraph, and power lines, and for fence posts. (6) *Wood pulp* for making paper, rayon, cellophane, and plastics. (7) *Tannin* from hemlock and oak bark, for tanning leather. (8) *Food* such as maple syrup.

Scientists have learned how to make use of the waste products of our

Study this illustration carefully. What uses of forest products are shown? (Canadian Forest Products Laboratory photo)

lumbering industry. Sawdust and other mill wastes are changed into materials such as wood alcohol, fibreboard, etc. These products have changed our ways of living and added to our comforts and conveniences.

**Why is our lumber industry important?**

The lumber business is one of the most important branches of Canada's great forestry industry. It supplies many of our daily needs. Our vast lumber resources also permit large shipments to other countries, thus increasing our international trade.

**SOMETHING TO DO**

1. (*a*) By reference to the Canada Year Book or other government publications, find the annual value of lumber production in Canada.

(*b*) What per cent of our lumber cut each year is exported?

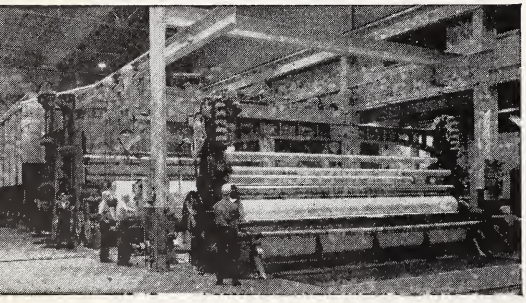
(*c*) Name the provinces of Canada that rank among the top three in value of lumber production.

2. Make a collection of samples of the different kinds of lumber used for building and for furniture. Try to include in your collection such "hardwoods" as oak, maple, birch, and such

Eight million board feet of Douglas fir ready for export.

Above: Wood pulp is wood that has been ground or cooked into mush. It is mostly water and has the same relationship to wood as applesauce has to an apple. In paper making, pulp flows onto a moving screen and then through driers where the water is removed. Paper is really a thin sheet of dried pulp.

Below: The dry end of a paper machine. Pulp flows onto the machine at the wet end and, in as little as ten seconds, emerges at the dry end, as a roll of paper, perhaps 200 inches wide. This is all the more remarkable when it is remembered that the distance between the ends of the machine may exceed 300 feet. Compare the width of the roll of paper coming off the machine with the height of the workmen whom you see in the picture. (Above, George Hunter photo; below, Canadian Pulp and Paper Association photo)



"softwoods" as spruce, pine, cedar, and fir. If you take time to cut your samples to the same size, plane them smooth, and then label them, your collection will have greater value.

### The pulpwood industry

Production of pulpwood in Canada averages about 10,000,000 cords per year. Spruce, fir, hemlock, jack pine, and poplar all are used in the manufacture of pulp; however, spruce is by far the most important. Logs from these trees are cut, floated down rivers, and transported by boats to pulp mills. Here they are cut into chips, ground into a soft mass, and boiled with chemicals to make pulp, which has many uses. (See illustrations on this page and on pages 131 and 267).

#### SOMETHING TO DO

1. Look around your school for examples of the various uses of paper and paper products. List these in your science note-book.

2. Compile a similar list of articles produced by the pulp and paper industry that you find in use in your home.

One of the most widespread uses of pulp is in the manufacture of *paper*. Many kinds of paper are produced, such as newsprint for newspapers, paper for towels, paper for books and magazines, writing paper, wrapping paper, handkerchiefs, napkins, wallpaper, and building paper. Pulp fibre is manufactured into hundreds of other articles including artificial leather, boxes, bottles and caps, cartons, felt, hats, twine, ribbon, surgical dressings, suitcases, table cloths, and wall boards.

We know that wood pulp is also used in manufacturing rayon for dress goods, shirts, and other wearing apparel.

Pulpwood is used in the production of many other *chemical products* of which cellophane, plastics, paints, explosives, and buttons are common examples.

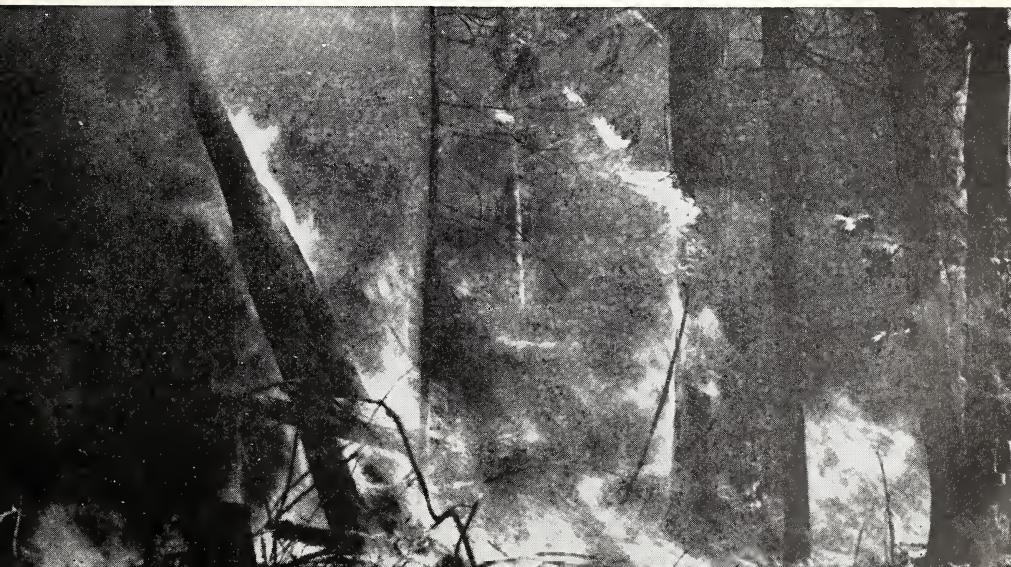
These things have been produced after many years of experimenting by scientists. It should be clear to us, therefore, that the discoveries of science which have developed the pulp and paper industry are of very great importance to us.

Thousands of Canadians depend directly on our forests and forest products for their livelihood. Canada's forest resources pay salaries and wages amounting to $760,000,000.00 per year. Indeed, the well-being, prosperity, and happiness of all the people of Canada are linked closely with our forest industries. Since the manufacture of pulp and paper products depends primarily on our forests, all of us should understand that it is in the best interests of our future welfare to make certain that our forests are not ruthlessly destroyed, but used wisely for the benefit of all Canadians — both present and future.

**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

1. Explain the value of our forests in the control of floods and soil erosion.
2. What is the importance of forests in respect to each of the following: wildlife; Canada's tourist trade; shelter belts on farms?
3. What are the values of a farm woodlot? What can a farmer do to conserve his tree crop?

A roaring forest fire that was caused by carelessness. Think of the terrible destruction of such a fire. (Ontario Department of Lands and Forests photo)



4. Tell in your own words the part played by the lumber and timber industry in Canada's industrial development.

5. By referring to specific products of the pulp and paper industry, tell a story that will show how closely this industry is linked with our daily living.

## HOW OUR FORESTS ARE ENDANGERED

Canada is above all a forest country. Forests cover more than 50 per cent of the land area of the ten provinces of Canada. Most of this land is suited only to the production of trees, and at least one-half of these forest areas are capable of producing, if proper methods are followed, crop after crop of trees. Thus nature has decreed that Canada's destiny must be closely linked with the proper use of her forests. What are some of the worst enemies of this great natural resource?

***Forest fires*** are one of the greatest agents of forest destruction, and unfortunately, nine out of every ten such fires are man-made. These fires annually cause millions of dollars of damage. They burn down strong stands of timber, they destroy the little seedlings that otherwise would grow into mature trees, and, by burning the humus out of the soil, they destroy its fertility. In addition, all wildlife, both plant and animal, is robbed of its food and protective cover, and people are deprived of their forest playgrounds (see the photograph below). With no forest covering, water from melting snow in spring and from heavy rains in summer no longer is held in check. Water erosion follows, causing a great waste of soil fertility. It is evident that the damaging results of forest fires are far-reaching. Everyone should make it his responsibility to help to prevent the 90 per cent of fires that are due to carelessness.

After the fire. All alone and nothing to eat! (Powell Equipment Co. Ltd. photo)

From time to time our forests are endangered by ***insects*** that feed upon the roots, the stems, or the leaves of trees. The *spruce budworm* (see illustration on page 333) attacks spruce trees of all ages by eating their leaves. It has been estimated that this insect alone has killed an amount of balsam fir and spruce equal to the supply required by the pulp and paper industry over a period of thirty years.

*Bark-beetles* usually attack overmature trees. The larvae or wormlike forms of these beetles feed under the bark of the tree. Sometimes, when their numbers are great enough, they kill a tree in a single season. The eastern spruce bark-beetle, for example, has killed extensive stands of valuable timber in Eastern Canada. Closely related species have caused similar losses in the Prairie Provinces and British Columbia.

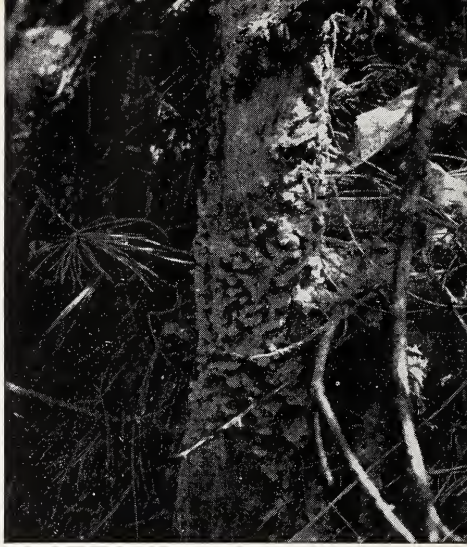
The *larch sawfly* and *European spruce sawfly,* which were accidentally introduced into Canada from other parts of the world, destroyed large stands of tamarack and spruce trees before they were brought under control. The *forest tent caterpillar,* described in Chapter 12, is another insect that damages the forest.

Trees, like people, are subject to many ***diseases.*** In the case of trees, the diseases are caused by fungus growths such as rusts and blights. Possibly the most destructive tree disease in Canada is the *white pine blister rust.* This fungus has an interesting life-history. It passes part of its life on currant or gooseberry bushes and part on white pine trees. It cannot spread directly from pine to pine. The rust fungus enters the green needles of the white pine and spreads until it affects the whole tree. The cambium or growing area underneath the bark is destroyed, and the tree dies. White pine blister rust can be controlled by destroying all currant and gooseberry bushes that are growing near white pine trees. Scientists have developed new species of white pine which are resistant to blister rust (see page 348).

This low-flying aircraft, with spraying machine mounted on a pontoon, is spraying budworm-infested spruce trees with a fine mist of deadly DDT. Inset: A spruce budworm feeding on spruce leaves. (National Film Board photo; inset, Ontario Department of Lands and Forests photo)

Other plant diseases that attack trees are *chestnut blight, butt-rot, heart-rot fungi,* and *oak wilt.* The

The tent caterpillar is an enemy of our forests. How does it damage them? (Ontario Department of Lands and Forests photo)



Left: A tree fungus called oyster mushroom. Above: White pine blister rust growing on and destroying a pine tree. Notice the white "blisters" on the trunk. (Left, Virginia S. Eifert photo; right, Ontario Department of Lands and Forests photo)

controlling of these and other fungus diseases requires the services of specially trained scientists called plant pathologists. To control the plant-disease pests that attack our forests, much research is required. The plant-diseases expert must know the life-history of the fungus and how it feeds and spreads before he can devise a way of checking it.

***Ruthless lumbering practices*** have been a serious threat to our forests. In the past, some lumbering companies have followed the short-sighted policy of *clear cutting* forest areas. In clear cutting, trees of all sizes and stages of growth — the mature, the half-grown, and the young saplings — are slashed down. This unwise and wasteful harvesting method leaves few, if any, young trees to grow into future forests. Fortunately this practice no longer is common in Canada.

**SOMETHING TO DO**

1. Make a survey of tree insects in your locality. Bring to school for identification several kinds of insects that you have found on trees. Be prepared to tell your classmates which kinds of trees they were on, and the kind and amount of damage that they were doing.

2. Collect leaves and wood from trees showing damage by plant diseases. Try to find in each case the name of the fungus responsible for the damage.

3. Discuss the use being made of the airplane in controlling forest insect pests. Can it be used for all such pests? What, if any, are the dangers of spraying large forest areas with insecticides?

**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

1. Give some evidence in support of the statement that "Canada is above all a forest country."
2. Make a list of the harmful effects of forest fires. Which of these do you consider to be the most serious? Why?
3. Name two insect pests that endanger our forests. What method or methods are used to control these insect pests?
4. Describe the life-history of the fungus that causes the white pine blister rust. How may this disease be controlled?
5. What is a plant pathologist? Why is his work important in forest conservation?
6. What is meant by "clear cutting" a forest? Is this a good practice to follow? Why?

## PROTECTING OUR FORESTS

Boys and girls of Canada who have learned to know and to enjoy trees, birds, wild animals, and wild flowers are not likely to be guilty of starting forest fires. Such young people can be a big help in spreading the warning of the danger that lurks in the burning match or the lighted cigarette or cigar carelessly thrown away among the dry leaves and grass of the forest floor.

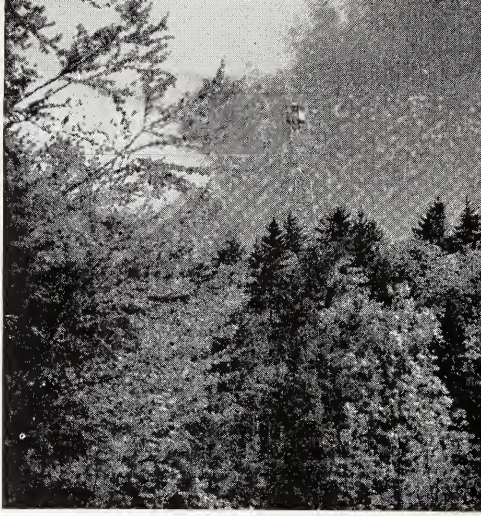
When you go into the woods to fish, hunt, hike, picnic, or camp and make a campfire, be sure you follow the precautions that are recommended. If possible your fire should be built on a wide, flat rock; otherwise you should scrape away all the leaves, dead twigs, and grass from an area several feet wider in diameter than your fire will cover. Build only a small fire and build it carefully. Before you leave camp, make sure that your fire is completely out. Douse it with pailful after pailful of water, stir up the ashes, and douse it some more. If even one ember is left glowing, a breeze may fan it into a flame that may spread and start a disastrous forest fire. You cannot be too careful with matches and campfires in the forest.

Boy Scouts build their campfires in safe places and make sure that they are really out before they leave them. Carelessness might lead to a fire which would destroy the forest and the prospect of future outings in this area. (Ontario Department of Lands and Forests photo)

Another common cause of forest fires is the burning of brush piles, often by farmers who are clearing land for cultivation. Brush should be burnt only on calm days in fairly damp weather. Every precaution should be taken to make certain that these fires do not get out of control.

Lightning may start forest fires, particularly in seasons of light rainfall. Such fires are unavoidable. An efficient forest fire service is essential to control these as well as the fires caused by man's carelessness.

Break your match. Be sure it is out. This is one way to make certain that it is cool enough not to ignite on the forest floor. (United States Forest Service photo)



From lookout towers, observers closely watch the forest for signs of fire. (Ontario Department of Lands and Forests photo)

### Fighting forest fires

Fire Detection. — This is the starting point in fire control. The sooner a fire is discovered and reported, the better will be the chances of bringing it under control before it has done untold damage. High *lookout towers,* usually with cabins on top, are erected at strategic points in forest areas. Each tower has a lookout man who remains on duty all day scanning the forest for miles around with high-powered binoculars or field glasses. If a fire is spotted, he determines the direction of the fire with a special instrument called a fire-finder. He telephones or radios this information to headquarters where it, and similar information from other observers, is projected on an aerial map of the area. In this way the exact location of the fire is calculated.

Often *aircraft patrols* work in cooperation with the lookout towers in locating fires. Such airplanes are equipped with radios for transmitting messages to headquarters. Several provinces in Canada maintain their own air services for this important work.

*Fire rangers* and the general public also assist in fire detection.

Transportation. — Once a fire has been detected and located, the next essential of good fire fighting is to get a well-trained crew and equipment to the scene of the fire with all possible speed. A small fire may be brought under control quite quickly, while it may require days or even weeks to extinguish a fire that gets out of hand. Various means of transportation, depending on the region and the nature of the terrain, are employed. Helicopters and other types of airplanes, motor trucks, railway gas cars, motor boats, canoes, and trains, all are used. Sometimes fire fighters must travel on foot and either carry their fire-fighting equipment and provisions, or have these dropped by parachute to them near the scene of the fire.

Control. — Small forest fires are sometimes held in check by "water bombing" them from an airplane until the fire-fighting crew travelling overland arrives on the scene. Tanks are filled with water from the nearest lake and are then dropped from the aircraft onto the fire.

The advance ground crew uses portable radios to advise headquarters of the nature and extent of the fire and what mechanical equipment will be needed to fight it.

Often an aircraft equipped with a loud speaker is used to direct the fire-fighting operations from the air. Pictures of the area are taken with an aerial camera. These are developed immediately and are an aid to those directing the suppression activities.

Lowering fire-fighting equipment from a helicopter. Fire fighters use the best machines and equipment that science can provide. (Ontario Department of Lands and Forests photo)

If a supply of water is available, portable gasoline power pumps and long lines of fire hose may be used by the ground crew, much as in the case of city fires.

Often a forest fire may be confined to a small area by using a bulldozer to remove all the inflammable material from a strip around the fire or by clearing a *fire guard* or *fire lane* with ploughs to stop the advance of the fire. Another method of control that sometimes has been used effectively in fighting forest and prairie fires is called "back firing." In back firing, the fire fighters start small fires which they can control and which will travel against the wind and in the direction of the main fire. This is

Fire fighting may include rescue work. This fire fighter carries a tiny fawn out of a burning forest to safety. (Ontario Department of Lands and Forests photo)

a case of "fighting fire with fire." The back fires burn all the inflammable material and leave a black fire guard behind them as they advance slowly toward the on-coming roaring fire. When the main fire reaches the burnt-over strip or the fire guard, its progress is halted.

The fighting of forest fires calls for close co-operation on the part of many people. In developing new equipment and methods in fire detection and control, science plays a major role.

**How may trees be harvested without waste?**

Conservation means using without waste. In place of the very undesirable practice of clear cutting, foresters recommend that a system of *selective cutting* be followed. In selective cutting, chiefly mature or full-grown trees, and trees that show signs of disease or damage by insects, are harvested. Mature trees should be cut before they begin to die (see page 297).

Canadian government foresters must approve of cutting methods and the area to be harvested. By careful management of a forest in this way, it is possible to provide for a permanent annual crop of timber and pulpwood in a forest area. This is called *sustained yield*. Thus, operators logging their timber stand can count on perpetual or continual operation. Since pulp and paper mills usually cannot be moved to new areas, it is essential that this policy of sustained or perpetual yield be followed.

All parts of the trees that are cut, including the branches, the stumps, and the bark, should be utilized for one purpose or another.

If properly cut, forests will rejuvenate themselves better by natural means than by artificial methods, such as reforestation. Therefore, in all lumbering operations, an adequate number of trees that are suited to reseeding the forest should be left standing for that purpose.

Special care should be taken to make sure that no sloping hillsides are left bare of trees. As you have already learned, by keeping a growth of trees on these slopes, dangers of flooding and soil erosion are avoided.

Science plays a very important role in the conservation of our forests. Indeed, science today enters into every aspect of forest operations from cutting methods to the health and well-being of the workers. Science provides not only improved tools, but has also contributed improved methods in the management of our forests.

**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

1. What is meant by "selective cutting" of our forests?
2. Show how selective cutting of forest areas leads to a policy of "sustained yield."
3. If a good system of forest conservation is being followed, can some of the trees be cut down and used? Explain.
4. (*a*) List at least three causes of forest fires that are the result of human carelessness.

(*b*) Name one cause of forest fires that cannot be attributed to man's carelessness.

5. Describe in your own words the methods used to fight forest fires. Your description should include answers to the following questions: (1) How are the fires detected? (2) What are the means of transport for men and equipment to the scene of the fire? (3) If no water is available, how is a fire controlled?

## STARTING NEW FORESTS—REFORESTATION

As you have already learned, the best way to get a new growth of trees in a forest area is to permit mature trees to reseed themselves. This is not always possible, as when an area is completely burned over by a forest fire, or when sandy, rough, or hilly land has been cleared of trees for agricultural use, only to have it discovered later that the land was unsuited for such a purpose. In these cases there are no trees present to produce seeds, so reforestation must be carried on by man. For example, forestry experts have investigated the situation in Ontario. They have estimated that 2,500,000 acres of land should be reforested for the purpose not only of producing more forest crops, but also of conserving water and soil. As a result, large areas of new forests have already been planted.

Reforestation has been carried on under the direction of the Forestry Branch of the Department of Lands and Forests. Forestry nursery stations have been established to demonstrate the values and the best methods of reforesting waste lands. These nursery stations have grown seedling trees by the millions for distribution and planting where required. The forester's first step is to gather seeds

Pines were planted by the thousands to reforest this area. (Ontario Department of Planning and Development photo)

from the kinds of trees to be planted. Tree fruits, such as the cones of the pine and the spruce, which contain the tree seeds, are gathered by the sackful in autumn and stored in a dry place until spring, by which time the cones will usually have opened and released their seeds. The seeds are then sown in seed beds containing well-prepared sandy loam soil. The necessary conditions for germination — warmth, air, and moisture — are provided. After the seedlings have germinated, they are kept shaded, weeded, well-watered, and protected from diseases and insects. In two years they are ready for transplanting into nursery plots. When these seedlings have reached a height of one to one-and-a-half feet, they are ready for use in reforesting waste lands and burned-over areas.

As you have learned, a similar program of growing trees from seeds for the purpose of establishing windbreaks, is carried on in the Prairie Provinces.

For good growth, different varieties of trees require different conditions of soil, moisture, shade, and climate. Jack pine and red pine do well on sandy soils with limited moisture. White spruce and white pine thrive in well-drained loam soils. Willows and cedars prefer swampy land. Although a variety of tree may prefer a certain type of soil, often it will thrive in a wide range of soil types and climatic conditions. The white spruce is such a tree. It is widely distributed all across Canada (see the illustration on page 325). All these matters are considered carefully when trees are being chosen for reforestation in the various regions of Canada.

#### SOMETHING TO DO

1. Gather different kinds of tree fruits and seeds, such as cones of evergreens, acorns of oak, nuts of hazelnut and butternut, winged fruits of maples and ash, and pods of caragana. Plant the seeds from each kind of tree in a shallow box filled with sandy soil. Water well. Cover the top of the soil with a sack or cloth. Keep warm and moist. Watch for the young seedlings to emerge from the soil. Compare the appearances of the seedlings of the different kinds of trees.

2. Plant some of the small seedlings that you have started, in a suitable location in the garden at school or at home. Keep them watered and weeded. Find how much they grow in one season.

3. Find how nature provides for the distribution and planting of the seeds of trees by squirrels, birds, and winds. Report your findings to your class.

4. If a tree-planting train comes to the district in which you live, make a point of visiting it.

5. Make the acquaintance of the forest ranger in your locality. Learn from him how to report a forest fire.

### TEST YOUR KNOWLEDGE AND UNDERSTANDING

1. Discuss this statement: "Wise use of our present forests will keep them always productive and valuable to Canada in many other ways."

2. (a) Reforestation is an important aspect of conservation. What is meant by reforestation?

(*b*) Under what conditions is reforestation advisable?

(*c*) Tell how reforestation is carried on by your provincial forestry branch.

3. An authority on the conservation of our natural resources, Dr. W. C. Lowdermilk, has written a short message entitled "The Eleventh Commandment," which is reproduced below. Study it carefully. What natural resources are mentioned? What methods of conservation are suggested? Failure to put into effect good methods of conservation will result in what disasters?

THE ELEVENTH COMMANDMENT

Thou shalt inherit the holy earth as a faithful steward, conserving its resources and productivity from generation to generation. Thou shalt safeguard thy fields from soil erosion, thy living waters from drying up, thy forests from desolation, and protect thy hills from overgrazing by the herds, that thy descendants may have abundance for ever. If any shall fail in this stewardship of the land, thy fruitful fields shall become sterile, stony ground or wasting gullies, and thy descendants shall decrease and live in poverty or perish from off the face of the earth.

### HELPING IN CONSERVATION

In your study of forests, no doubt you have become interested in our native trees. Quite likely you have developed a good attitude toward the conservation of this important natural resource. Here are a few ways in which you can help to conserve our forest trees:

1. City and town parks, as well as rural areas, have trees that you can help to protect. Never peel bark from the birch or any other tree.

2. Help to make your school grounds into a conservation area where wild flowers, birds, and other wildlife can live in safety.

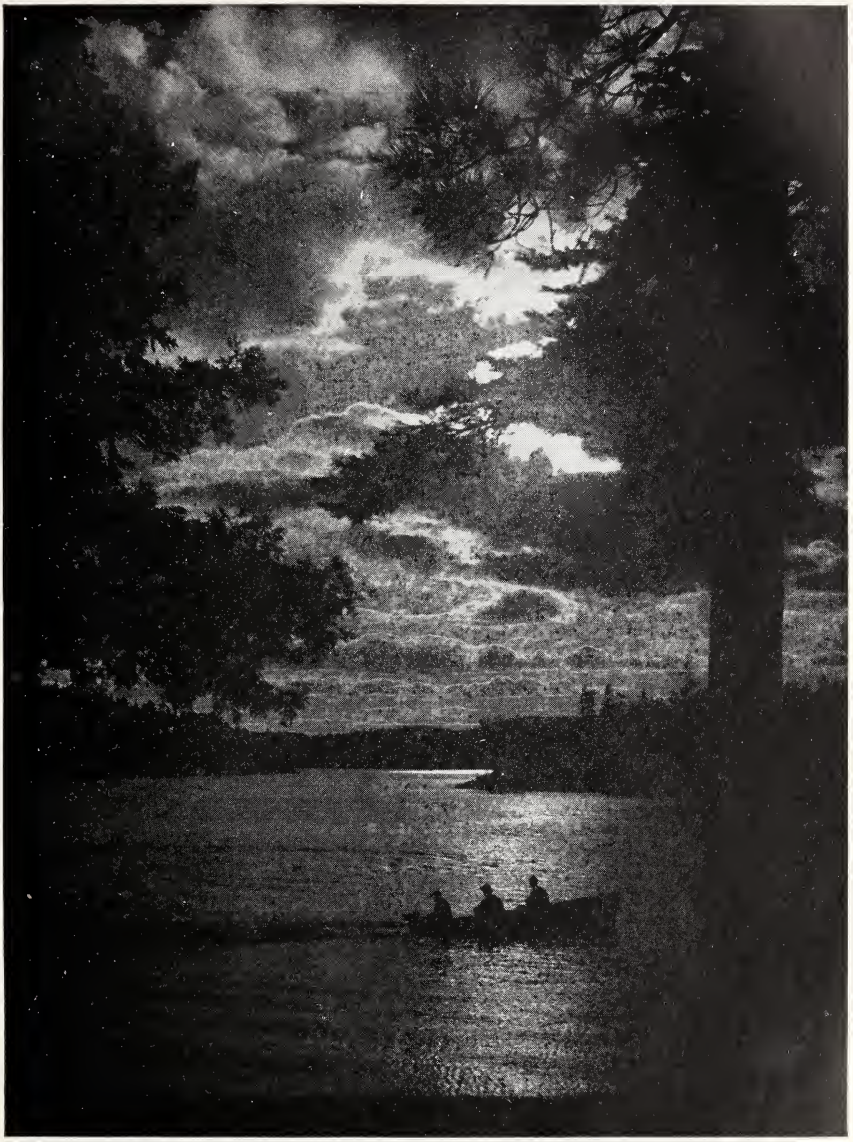
3. Set a good example when hiking, picnicking, fishing, or camping in the forest, by building your campfire in a safe place and

These boys and girls are planting evergreens on their school grounds. A part of the school yard will be reforested by this method. If the trees are to grow, what care should the pupils give them after they have been planted? (Ontario Department of Lands and Forests photo)

making sure it is really out before you leave, by not cutting or breaking down young trees, by not destroying birds' nests, or picking wild flowers only to throw them away.

4. Visit places where conservation is being practised, for example, a forestry station, reforested area, unpastured farm woodlot, P.F.R.A. dam.

5. Try to develop the habit of thinking about our natural resources from the conservation point of view. By learning to use wisely our soil, water, forests, and wildlife, you can help to maintain a perpetual yield of their products for future generations.



All of us should do everything we can to preserve beautiful tranquil scenes such as this for future generations to enjoy. (Ontario Department of Lands and Forests photo)

## WHAT HAVE YOU LEARNED?

### IMPORTANT SCIENCE IDEAS AND UNDERSTANDINGS

A

1. Differences in leaves, flowers, fruit, bark, and general shape, are the means of identifying various kinds of trees.
2. Forest trees bear flowers and produce fruit and seeds just as many other plants do.
3. Trees are divided into two main groups according to the shape of their leaves: (1) broad-leaved, (2) needle- or scale-leaved.
4. Broad-leaved trees are also known as deciduous or hardwoods; needle- or scale-leaved trees are conifers or softwoods.
5. The forest industries of Canada, which include lumbering and pulp and paper manufacture, rank among our most important industries.
6. Besides supplying large quantities of valuable products, forests are of great benefit to Canada in many other ways.
7. Canada's future prosperity is closely linked with the wise use of her forest resources.
8. A farm woodlot, if properly managed, will supply a farmer with a continuous crop of wood and also with other benefits.
9. The chief enemies of our forests are: forest fires, insect pests, plant diseases, and ruthless lumbering practices.
10. Science plays a very important part in helping to control the enemies of the forest.
11. By following the policy of selective cutting of forests, it is possible to provide for a continuous or sustained yield of trees.
12. Most forest fires are the result of carelessness.
13. Successful control of forest fires depends on early detection, rapid transportation of well-trained fire-fighting crews and equipment to the scene of the fire, and adequate methods of suppression.
14. Reforestation of waste lands and badly burned-over areas is an important part of forest conservation.
15. Conservation of forests, water, soil, wildlife, and recreation areas is essential to the good and welfare of all Canadians, both present and future, and is a responsibility of every citizen.

(a) The foregoing sentences are all true statements of important science ideas and understandings. Read and discuss them carefully as a review of this chapter.

(b) The following sentences describe situations in which some of the ideas in A apply. To test your ability to apply ideas to actual situations, match sentences in A with situations in B to which they apply.

B

1. During a class discussion in a science period, Walter Forbes reported reading the following statement by the Canadian Forestry Association: "Most of the world's newspaper readers take their information from sheets of newsprint that once grew in Canadian forests. Over 400,000,000,000 sheets of standard newspaper size are whirred from the machines of Canada's paper mills each year."

2. A Canadian newspaper recently carried this news item: "The fast-spreading tree-farm movement, aimed at eventually giving Canada a perpetual supply of wood by managing timber as a crop, has led to the certification of hundreds of tree farms. The farmers on these tree farms have agreed to maintain their woodlands for growing forest crops, to protect the woods, to adopt cutting practices that would ensure future crops, and to allow foresters to inspect their farms."

3. The Jones family went on a camping trip to a national park in the summer holidays. Unfortunately, they did not build their campfires properly and sometimes they failed to make sure that their fire was completely extinguished before they left.

4. One of Canada's veteran fire rangers offers these hints to campers, sportsmen, and others entering the woods for recreation: "A small campfire cooks better and it's easier to extinguish. Build it on rocks or in a well-cleared circle of mineral earth. Then finally douse it with water. That's the way to play safe."

5. While hiking in the woods in spring, Joan Wilson and Edith Brown noticed a poplar tree with many catkins hanging from its twigs.

6. Joan and Edith observed that many of the forest trees were naked, while others had kept their leafy covering all winter.

7. Miss Peterson's class examined a copy of a proclamation issued by the provincial government which declared the first week in June to be "Forest Conservation Week." The proclamation listed the various ways in which our forests benefit all the people of the province, either directly or indirectly, and then made the following appeal: "That during Forest Conservation Week all citizens be urged to develop and to foster an informed pride in the extensive forests, natural woodlots, and planted shelter belts throughout the

province; to dedicate themselves to the support and encouragement of all measures aimed at the conservation and wise management of our forests; and to reduce the menace of forest fires by exercising the utmost care in the use of fire in or near such forests." All members of the class decided that as good citizens they should do their best at all times to carry out the objectives of Forest Conservation Week.

8. On a certain farm in Ontario, all the trees on the hills had been cut and sold or used for fuel. The owner of the farm observed that the springs, which formerly had supplied ample drinking water for his livestock during the hot summer months, were now reduced to mere trickles. He reasoned that the bare hillsides were partly responsible for the drying up of the springs and decided to plant trees again on the sloping areas.

## IMPORTANT SCIENCE TERMS

A

| | | |
|---|---|---|
| staminate flowers | deciduous | white pine blister rust |
| pistillate flowers | evergreen | plant pathologist |
| simple leaf | hardwoods | clear cutting |
| compound leaf | softwoods | selective cutting |
| terminal bud | pulp | sustained yield |
| lateral bud | rayon | reforestation |
| lenticel | spruce budworm | conservation |

To show that you understand and can use the science terms listed in A, match with the situations described in B those terms which apply.

B

1. By learning to use our forests wisely, Canadians can benefit in many ways both now and in the years to come.
2. By scientific forest management, it is possible to provide for a continuous supply of trees for our forest industries.
3. Broad-leaved trees such as oak, elm, birch, and maple shed their leaves in autumn.
4. The leaves of the ash, the butternut, and the Manitoba maple have blades composed of leaflets.
5. Insect pests and plant diseases annually destroy very large numbers of forest trees in Canada.
6. Poplar trees grow their flowers in two kinds of catkins; one kind produces pollen and the other produces seed.

7. Farmer Wayne followed the practice of harvesting from his woodlot only the mature trees or the trees showing signs of damage by disease or insect pests and of leaving the others to grow to maturity.

8. Buds on the sides of tree branches usually grow into leaves or flowers, but sometimes they also produce new twigs.

9. Generally speaking, it is easy to drive nails into the wood of balsam, spruce, fir, cedar, and pine trees.

**SCIENTIFIC METHOD AND ATTITUDES**

1. Ben Olson noticed that the pine trees in the shelter belt on his father's farm were turning brown in color. He wondered what he could do about it. In which of the following circumstances would Ben be showing a scientific attitude?

(*a*) He assumed that there was nothing to worry about for the trees would turn green again after the next heavy rain.

(*b*) He examined a number of trees carefully to try to discover if insect pests or plant diseases were causing the needles to turn brown.

(*c*) He reported his observations to the nearest forestry station and asked what was causing the leaves to turn brown, and what should be done to save the trees.

(*d*) He decided that the pines wouldn't suffer much harm should their needles drop off, for they would grow a new crop of green needles next spring.

(*e*) He made a survey of other tree windbreaks in his locality to discover if the same problem existed on other farms and then reported his findings to his provincial forestry branch.

2. Scientists in the Forest Biology Division of the federal government were asked to find a way to control an insect that was injuring spruce trees in some forest areas in Canada. First of all, these scientists, who had special training in the field of insect pests, made a thorough study of the damage being done by this newly-discovered plant enemy. They used high-powered microscopes to study the appearance of the insect causing the damage and compared its structure with that of other insect pests with which they were familiar. They experimented with the insect in an effort to learn more about its life-history. They wanted to find out, for example, what different stages it passed through and if all these stages were to be found on the spruce tree. After gathering these and other facts, and on the basis of past experience, they

This plant pathologist or scientist has developed a species of white pine that is resistant to the blister rust. The pots contain seedlings of the rust-resistant white pine. (Ontario Department of Lands and Forests photo)

finally decided that the insect probably could be controlled best by spraying the trees with a chemical known as *malathion.*

To test this possible solution, they selected a forest area where the new insects were widely spread. They selected twenty badly infested trees, ten of which they sprayed with malathion. On the ten trees which were left unsprayed they placed identification marks.

Two weeks after the spraying was done, the scientists made a careful study of the sprayed and the unsprayed trees.

(*a*) What steps of the scientific method were followed in the solution of this problem?

(*b*) Assuming that the scientists found that all insects on the treated trees were killed, would they be justified in reaching the conclusion that spraying with malathion will control the disease? Why?

(*c*) In case they found that the one spraying with malathion of a certain strength did not check the insect, would they be right in concluding that the disease cannot be controlled by malathion? Why?

Ontario Agricultural College

*I have seen the largest seeds*
*Degenerate, unless the industrious hand*
*Did yearly cull the largest.*

*—Virgil*

# CHAPTER 10

CHAPTER 10

# FROM SEEDS TO PLANTS

**What is a seed? How are seeds formed? How does a seed become a plant? How are seeds adapted for their work? When pea seeds germinate, they absorb enough water to double their weight. How does the water get into the seeds? How can you recognize good seed? Why is registered seed good seed to sow? In what ways is a vegetable garden an aid to healthful living?**

ON A WARM, SPRING-LIKE DAY during the Easter vacation, Joan Wilson and her cousin, Edith Brown, from the city, went on a nature hike across the fields to a valley not far from the Wilson's farm. As they tramped along, they observed on every hand many signs of spring. Joan's father was preparing the soil for planting grain. The hillsides were tinted with the rich green of the young grass. Crows flew overhead, breaking the stillness of the spring morning with their familiar cawing. Young lambs with gangling legs frisked about their mothers in the pasture.

Suddenly Joan exclaimed: "Oh, see what I've found — a duck's nest, with ten eggs in it! And I almost stepped on it."

"I just love spring," said Edith with enthusiasm. "It's such fun to see the baby animals and birds, and the wild flowers that bloom so early."

In the field and on the hillside the girls found hundreds of tiny plants pushing their first leaves through the moist soil.

"Where do all these little plants come from?" asked Edith.

"Why, from seeds, of course," answered Joan.

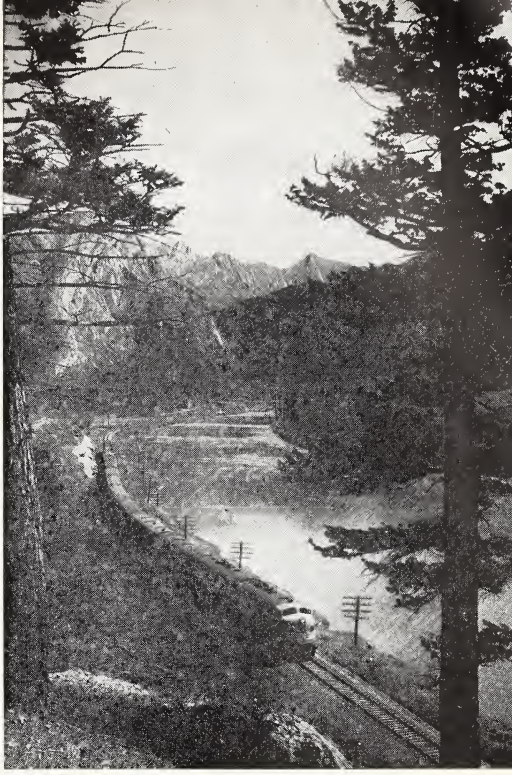
"I wonder what kinds of plants they'll grow to be. Do you think they'll have flowers, Joan?"

Joan stooped down to look more closely. "Here is a plant that has leaves like grass," she said, "and grass doesn't have flowers, does it?"

"I don't know; let's ask your father when we get home," was the reply.

When the girls asked their question, Mr. Wilson explained to them that plants which grow from seeds must of necessity have flowers, which, in turn, produce more seeds. "And to this rule," he said, "grass plants are no exception. But the flowers of grass plants, including wheat and oats, are not brightly colored, and so the casual observer may easily overlook them. Isn't it wonderful that from a seed that is put into the soil there will grow a living plant like the one from which the seed came? Imagine what confusion there would be if this were not true!"

Mr. Wilson was called away before Joan and Edith had nearly finished plying him with questions about seeds. They wanted to ask him, for example: Is the seed alive before it starts to grow? What causes a seed to grow? Why does it produce a plant like the one from which the seed came? How can a farmer or a gardener find out whether his seed will grow?



The trees that add to the beauty of this scene in the Canadian Rockies grew from seeds. When seeds from these trees fall into the river, they are carried down stream to new locations where they take root and grow. (Canadian Pacific Railway photo)

## FINDING OUT THE MARVEL OF SEEDS

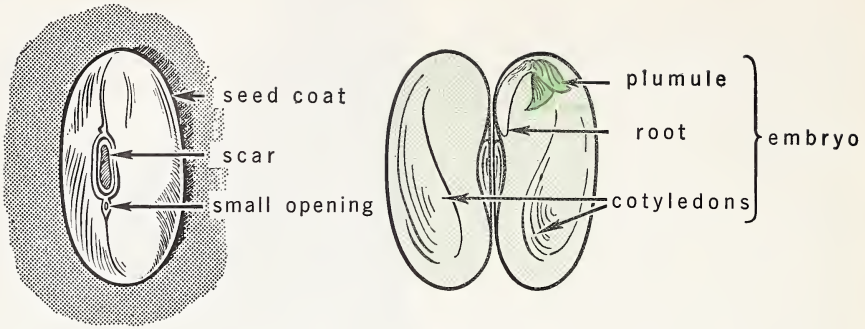
The girls decided to experiment to find the answers to their questions about seeds. You can learn the answers by the same method. *Be sure to study the seeds themselves* — not just diagrams in a book. The important thing in this kind of science activity is to do as much as you can yourself. By so doing, you are developing the methods and attitudes of a scientist.

### SOMETHING TO DO

*Problem.* — How is a bean seed adapted to grow into a plant?

*Materials.* — Enough dry beans and beans that have been in water overnight to provide one of each for each member of the class; a magnifying glass.

(*a*) Compare a dry bean with one that has been soaked, and note any difference in external appearance, size, and weight. The skin-like outer covering is a *seed-coat.* It is waterproof, and so




Left: An external view of a common bean. Right: A bean seed split open. Have you found the same parts in your specimen?

helps to keep the seed from drying out completely. Find the *scar,* which shows where the bean was attached to the pod. Close to the scar locate a small opening in the waterproof skin. When the seed is in water or planted in moist soil, this opening admits moisture, which is needed for germination.

Make a labelled drawing to show the external structure of a bean seed.

(*b*) Split open a bean that has been soaked, and examine its internal structure. Notice that it divides into two nearly equal parts. These halves are the seed-leaves, or *cotyledons;* they serve the young seedling temporarily as both food and leaves. They also serve as leaves after the seed has germinated. Observe the small, plant-like structure lying between the cotyledons. Note the *plumule.* This is the first bud of a plant growing from a seed. It develops into stem and leaves. How many leaves do you find, and how are they veined? The end opposite to the plumule is the *root.* The plumule and the root, together with the cotyledons, form the *embryo.* Examine the embryo under a magnifying glass.

Using the seeds you have been examining, make labelled drawings to show the internal structure of a bean seed. Do not be content to copy drawings from a book — a true scientist makes his own drawings.

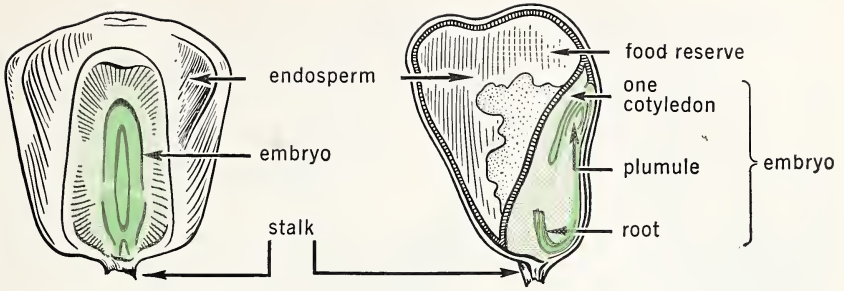
Common examples of seeds that closely resemble the bean in structure are peas, pumpkins, cucumbers, radish, squash, peanuts, and sunflower. If possible, you should examine some of them to find in what ways they are all alike.

#### SOMETHING TO DO

*Problem.* — How is a corn grain suited to produce the roots, stems, and leaves of a new plant?

*Materials.* — Each pupil will need: two grains of corn that have been soaked overnight in water, a sharp knife or safety razor blade, a magnifying glass.

(*a*) Carefully examine the external features of the corn kernels. Notice the depression in one side of the kernel. Under this lies the *cotyledon.* There is only one cotyledon in corn. Surrounding the cotyledon is the *endosperm,* which




Left: An external view of a corn kernel. Right: A lengthwise section through the corn embryo. What is the purpose of the food reserve?

contains the food reserve. In golden corn, the endosperm is yellow, and the cotyledon is white. The seed is protected by a hard outer covering, or *bran.* Find, at the small end, the *stalk,* by which the kernel was attached to the cob.

Make a labelled diagram to show the external appearance of a grain of corn, using your corn kernel as a pattern.

(*b*) Separate the cotyledon from the endosperm. Embedded in the cotyledon find a slender, pointed structure. The end pointing toward the broad end of the kernel is the *plumule;* the other end is the *root.* The plumule and the root, together with the single cotyledon, form the *embryo* plant of the corn. Examine it under the magnifying glass.

Cut a lengthwise section through the middle of the embryo in your second kernel of corn. Find the parts as before, namely, endosperm, cotyledon, plumule, root, stalk, and outer covering.

Make a labelled drawing to show a lengthwise section through the embryo of a kernel of corn, then check with the diagram above.

Examples of plants that produce seeds having the same parts as corn are wheat, oats, barley, and the various kinds of grasses. These plants resemble one another not only in their seeds, but also in their roots, stems, and leaves. They all belong to the grass family.

#### SOMETHING TO DO

Examine a number of other seeds to find out which are like the bean and which resemble the corn in structure. Be sure to soak some of each kind of seed for a while before you study them.

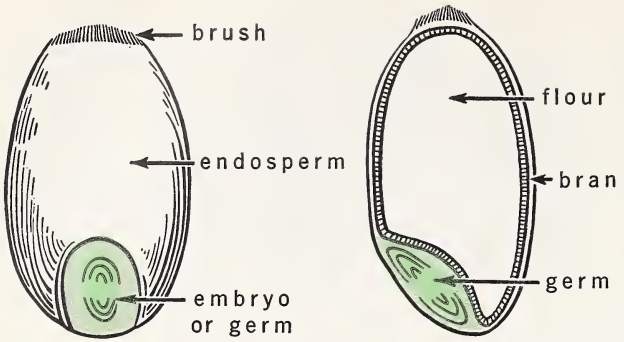
### Food stored in seeds

The seeds of various plants supply us with much of our food. Beans, peas, and sweet corn are important vegetables in our diet. The seeds of such grain crops as wheat, oats, and barley provide us with cereals and the flour used in making bread and pastry.

#### SOMETHING TO DO

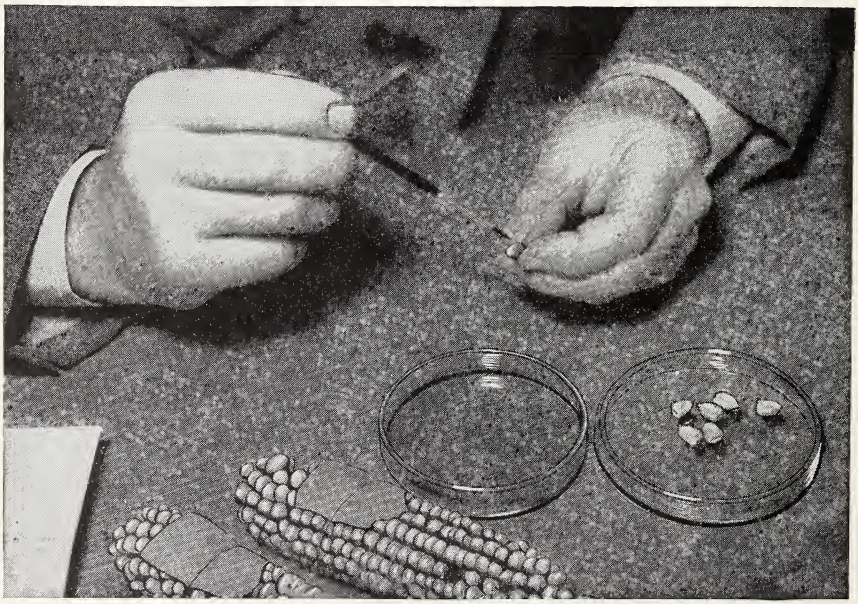
*Problem.* — What foods are stored in seeds?

You have already learned from your studies on pages 41 and 42 a way to




A wheat kernel. Which does it resemble more closely, a bean seed or a corn kernel? Why? Give a reason for your answer.
What use do we make of the food stored in the endosperm? Of what value is the bran?

test for starch, which is one of the foods commonly stored in plants. Split open beans, peas, corn, squash, and other seeds that have been soaked in water. On the exposed inside of each seed, drop some weak iodine solution, and allow the seeds to stand for a few minutes. Which parts of the seeds turn blue or purplish black? What does this indicate? Is starch stored in the embryo



Scientist testing individual corn grains for starch. He is applying iodine solution to cross-sections of the grains by means of a fine paint brush. (United States Department of Agriculture photo)

of a bean or pea seed? Observe that in corn and wheat, starch is stored chiefly outside the embryo – in the endosperm. For what purpose do plants store food in seeds?

In addition to starch, many seeds also store sugar, proteins, oils, vitamins, and minerals.

A newly germinated plant cannot make plant food. Until it has enough leaves and roots to provide all the food it needs, it must depend on the food stored in the seed. The greater the supply of this stored food, the more vigorous the seedling should be and the more rapid its growth. As a result, it will be less likely to be blown out by winds, crowded out by weeds, damaged by plant diseases, or destroyed by insect pests.

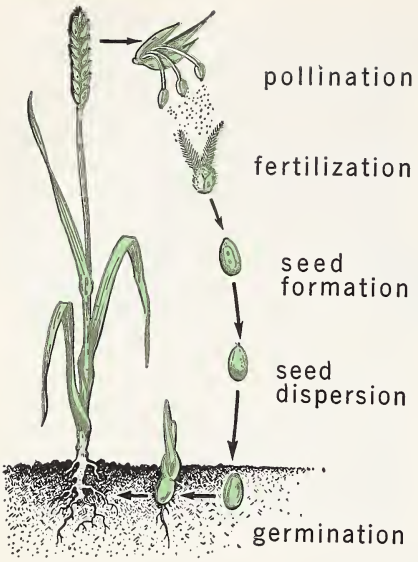
The seed's habit of storing a food supply is of great importance not only to the plant but also to man. We use the starch, sugar, protein, and oil contained in seeds. From wheat we get flour for bread, cakes, pastry, macaroni, and other dishes, and a wide variety of prepared breakfast foods. Oats supply our oatmeal. Corn provides our corn flakes, cornmeal, corn syrup, and cornstarch. Castor oil is obtained from castor beans; and linseed oil, so widely used in paints, is oil from the seeds of flax.

#### TEST YOUR KNOWLEDGE AND UNDERSTANDING

1. Describe the structure of a common bean seed. What is the function of each part of the seed?
2. Describe both the external and the internal structure of a kernel of corn. Use drawings to assist you. How is the kernel fitted to grow into a corn plant?
3. Why do plants store food in seeds? In what forms is the food stored? State at least three uses that we make of this food reserve.
4. Is a seed alive before it is planted? Give proof in support of your answer. How has your study helped you to appreciate the wonder of a seed?

## THE GERMINATION OF A SEED

It is well known that the seeds of some plants will grow, if planted, even after they have been kept in a dry place for years. Doesn't it seem wonderful to you that a tiny plant can remain asleep for ten, fifty, or a hundred years, and then, like the Sleeping Beauty, suddenly be awakened by the touch of the warm, moist soil? This awakening from the dormant or resting condition, in which the embryo plant shows practically no signs of life, to a state of active growth is called *germination.*




The life cycle of a flowering plant. Follow the arrows, and explain the importance of each process in the life of the plant.

Seeds are said to be germinated when the root and plumule have broken through and project beyond the seed covering, but germination is not complete until the little plant is able to live independently of the stored food in the seed.

It is important for the farmer and the gardener, and interesting for all of us, to know what are the most favorable conditions for germination.

#### SOMETHING TO DO

*Problem.* — What conditions are necessary for germination?

1. Place ten beans (or other seeds) in dry sawdust or soil in a warm room. Put an equal number of the same kind of seeds under the same conditions, but keep the soil moist. After a few days, observe which seeds have germinated.

2. Plant beans (or other seeds) in soil in two flower-pots or cans. Water both. Keep one container in a warm place and the other in a decidedly cool place. Examine them in a few days. Which seeds have sprouted? What does this show?

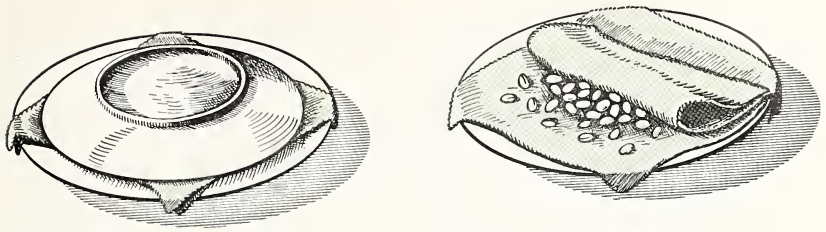
3. Plant beans (or other seeds) in soil in two separate pots. Keep the soil in one pot moist but not soaked, and the soil in the other pot fully saturated or flooded at all times to keep air away from the seeds. Place both pots in a warm place. Do the seeds in both pots germinate? If not, why not?

4. Plant beans (or other seeds) in soil in a pot. In the bottom of a second pot containing no soil, place a piece of blotting paper. Put an equal number of the same kind of seeds on it. Cover the seeds with another sheet of blotting paper. Add water to both pots to keep the seeds moist. Keep both lots warm. Do the seeds in both pots germinate? Is soil necessary for germination?

5. Again plant equal numbers of the same kind of seeds in soil or sawdust in two pots. Put one pot in a dark cupboard and keep the other in the light. Add water as needed to keep the seeds moist. Keep both lots of seeds warm. Do the seeds in both pots germinate? Is light necessary for germination?

What conditions do you conclude are essential for the germination of seeds? Is it possible to supply seeds with too much of any of the things they require?

Your experiments have shown that, to bring about a quick and healthy germination of seeds, they must have



A simple but useful germinator.

warmth, air, and moisture. You may have been surprised to find that soil and light are not necessary for germination. You may have noticed how easily a trodden road sheds rain, while a newly ploughed field or garden absorbs all that falls on it. The soil, then, should be broken up, or made friable, by cultivation, so that it will admit the necessary air and warmth and be able to hold a large amount of water. Clay soils may be made more friable, and less likely to become hard, by the addition of rotted manure, straw, leaves, sand, sifted soft-coal ashes, or wood ashes.

**How can a farmer or gardener tell whether his seed will grow?**

You cannot always determine by looking at seed whether or not it will germinate even if conditions are favorable. Farmers have sometimes seeded large acreages, only to discover later that the embryos in the seeds were dead. What a costly mistake to make! Sowing poor seed may result in very serious losses in both crop and labor. No farmer, therefore, can afford to sow seeds of doubtful germination strength. Nor is it sufficient for the farmer to know merely that the seeds are alive and will germinate; he should know also that they will sprout quickly and produce vigorous seedlings which will soon become firmly established in the soil. Why?

To determine whether seed is suitable for sowing, it should be tested for germination. To be of any value, the tests must be made with *average* samples from the package or the bin of wheat or other grain that is to be used for seed. The germinating strength of these average samples is then determined by performing a number of experiments and taking the average of the results obtained. Why? The following is a simple method of conducting such tests.

**SOMETHING TO DO**

*Problem.* — Is there any difference in germinating strength between plump, high-quality wheat and thin, low-quality wheat?

*Apparatus and Material.* — Four dinner plates, paper towels or blotting paper, samples of plump wheat and of shrunken wheat.

*Method.* — Put two or three layers of the paper in the bottom of each of two

dinner plates. Thoroughly wet the paper. Count out one hundred plump seeds and spread them over the blotting paper in one plate. Arrange one hundred kernels of the shrunken wheat similarly on the second plate. Cover the seeds with another piece of blotting paper. Invert a dinner plate over each of the plates containing the wheat. Keep them in a warm place. Pour in enough water from time to time to keep the blotting paper wet, without having the seeds standing in water.

Make observations daily for a week. Each day move to the side of the plate those seeds that have germinated both root and plumule. Good wheat should germinate 75 per cent in three days. Keep a record like that suggested under *Observation* in the next coloumn.

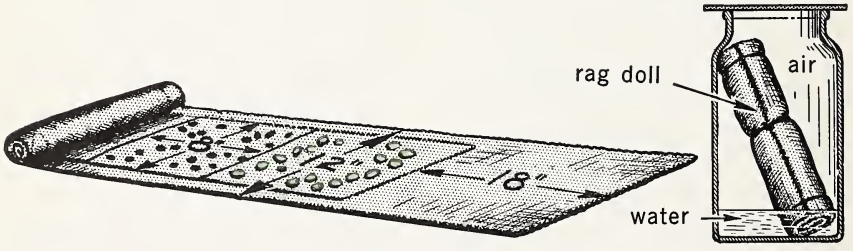
NOTE. — As an alternative, a *rag-doll germinator* may be used. For instructions on how to do this, refer to the illustration below.

*Observation.* —

| LENGTH OF TIME IN DAYS | PERCENTAGE OF SEEDS GERMINATED | |
|---|---|---|
| | HIGH-QUALITY WHEAT | LOW-QUALITY WHEAT |
| 2. | | |
| 3. | | |
| 4. | | |
| 5. | | |
| 6. | | |

Which sample of wheat germinated the higher percentage? Which germinated the higher percentage in three days? Which had the greater number of vigorous shoots?

*Conclusion.* — What does the experiment show regarding the germinating strength of large plump wheat and of




The Rag-Doll Seed Germinator and Tester

To make a rag-doll germinator: Cut a strip of fairly heavy flannel or cotton ten or twelve inches wide and one yard long. A sugar bag may be used. With a soft lead pencil, mark off squares as indicated in the diagram. Dampen the cloth. Place fifty large or a hundred small seeds in each square. Seeds must not touch one another. Roll up the cloth, and loosely tie each end and the middle of the roll with elastics or strings. Soak the roll in a pail or jar of luke-warm water for several hours. Pour out all but about one inch of the water, then stand the rag doll on end in the water. Keep it in a warm place. After five or six days the roll may be opened and a count made to determine the percentage of seeds that have germinated.

small shrunken wheat? How do you account for these results? Which sample would produce the more vigorous seedlings?

*Application of Experiment.* — 1. Test your father's seed grain or garden seeds to determine their germinating strength and fitness for use. Be sure to mix your seed well to get a fair sample.

2. Give as many reasons as you can why only good, plump seed of high germinating quality should be sown. Why are strong seedlings as important as a high percentage of germination?

### How a seed grows into a plant

Under favorable growing conditions, the embryo of a seed sends roots down into the soil and leaves up out of the soil, thus establishing the plant on a self-supporting basis. To see this interesting transformation taking place, set up the following experiment, and watch the development of the embryo from day to day, as it is awakened to active growth.

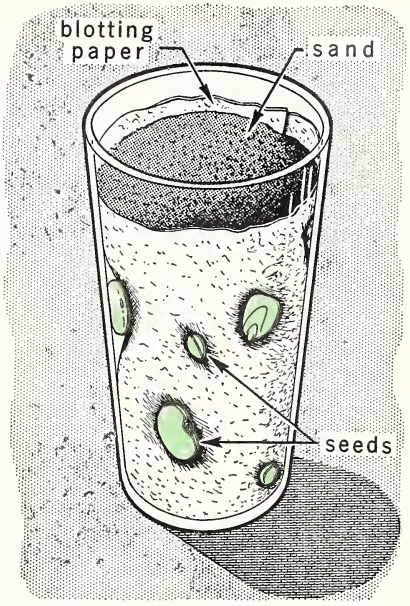
NOTE. — This experiment should be set up as soon as the study of seeds is begun. *Each pupil should perform the experiment for himself, either at home or at school.*

#### SOMETHING TO DO

*Problem.* — Do the embryos in different kinds of seeds grow into plants in a similar manner?

*Apparatus and Material.* — Line a glass with blotting paper and fill the glass with sand (see diagram.) Plant several kinds of seeds such as bean, pea, corn, and wheat, some in the sand and some between the paper and the glass.

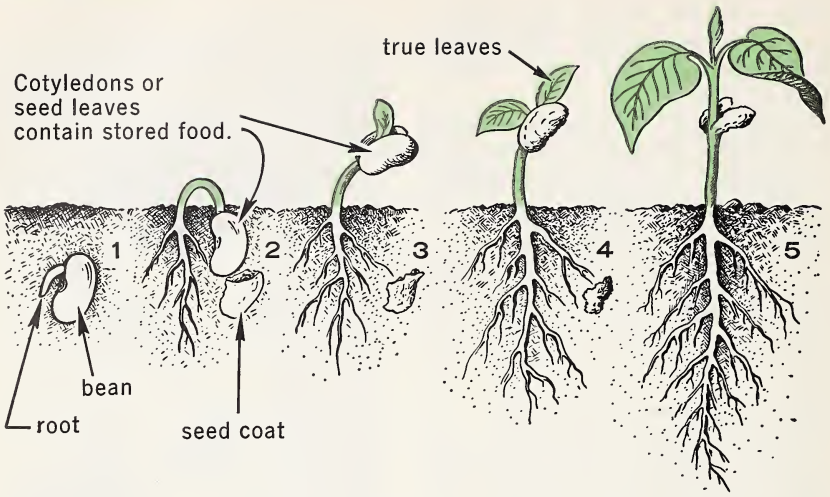
Soak the sand with water. Keep it in a warm place, out of direct sunlight.




An experiment in germination.

Add sufficient water from day to day to keep the sand and blotting paper moist, without having water collect in the bottom of the tumbler.

The progress of germination should be carefully noted daily. *A set of drawings should be made to show the method of germination of each kind of seed. Begin your drawings on the second day after you set up the experiment, and make additional drawings every two days for two weeks or until the seedlings are well developed.* The drawings in your textbook should be used only as a guide; you should not copy them. By making your own drawings from first-hand observations, you will train yourself in the skills of accurate observation and careful recording of what you see.




Stages in the germination of the common bean. 1. Root emerges first; seed coat still in place. 2. Side roots develop; plumule grows and pulls cotyledons out of seed coat. 3. Cotyledons serve as leaves for a time. 4. True leaves emerge. 5. Bean fully germinated.

*Observation.* — Watch to see which part of the embryo, the root or the plumule, emerges from the seed coat first. Look for the development of root hairs. Observe how the two cotyledons of the bean are lifted up. Does the same thing happen with the cotyledons of the pea? Does the single cotyledon of corn or wheat appear above the surface? Watch the seedlings as they come up through the sand. Which seeds *push* and which *pull* their leaves above the surface?

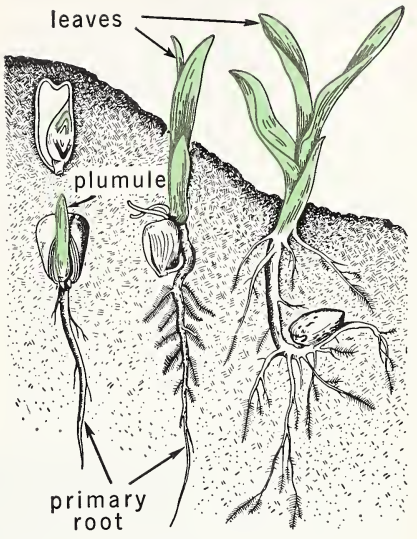
*Conclusion.* — In what different ways do the dormant plants in different seeds awaken and grow?

*Application.* — Observe seedlings that are growing in your garden, or seedlings that you are starting in flower-pots in the house. Which pull their leaves above the ground like the bean? Which germinate like the corn? If the soil is packed hard, young bean plants cannot get through it. Why? Would wheat have the same difficulty?

If a common bean is planted in soil under favorable conditions, it at once begins to absorb moisture, thus causing the cotyledons to swell and to burst the seed coat. The little plant-like structure, which hitherto has lain inactive in the dry seed, now becomes active and begins to require food. This it secures, for the time being, from the supply stored for that purpose in the cotyledons. The root grows out from between the cotyledons and becomes firmly established in the soil. Thus rooted, the plant pushes up toward the sunlight and the air, assuming a peculiar crook-neck shape as it lengthens. With its

inverted free end, it pulls the cotyledons after it. Once it has brought these to the surface, it straightens up and lifts them to the light. The cotyledons now spread out and expose the true leaves. Established thus with root, stem, and leaves, the plant is now able to produce food for itself. The germination process is complete.

In the development of its seedling, corn differs from the common bean in several ways. The cotyledon of corn remains in the soil. It assists growth by digesting the starch of the endosperm, thus changing it to sugar, a form in which it can be used by the developing plant. The plumule of corn has a sheath-like covering over the leaves, which are wrapped closely together to form a slender cone that pushes straight up through the soil with little effort.




The germination of corn. Compare this illustration with the drawing of the germination of a bean seed on page 360. What differences do you notice between the two?

**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

1. Define or explain the meaning of germination. When is germination complete? Draw a young bean or corn seedling.
2. State three conditions that are necessary for germination.
3. Describe the development of (1) a bean seedling, (2) a corn seedling.
4. Why are germination tests important? Describe an experiment by which you could determine the fitness of a sample of grain for seeding purposes.
5. Compare bean and corn seeds in regard to (1) structure, (2) method of germination.
6. How are seeds adapted for the work they do? In answering, bear in mind the seeds that have been studied in this chapter.
7. The best temperature for the germination of wheat and oats is from 50° to 68° F.; for pumpkins and corn from 68° to 86° F. Which of these plants are suited to early spring seeding, and which to late? On about what dates are they usually planted in your locality?

## GOOD SEED PAYS

Many factors that affect the growing of crops are beyond the farmer's or the gardener's control. He cannot, for example, regulate the amount of sunshine or rainfall, or prevent the occurrence of hailstorms or frosts. But one factor he can and should determine — the quality of his seed. It is usually possible to obtain good seed with little extra effort or cost.

The wise farmer or gardener sows only the choicest seed he can secure, because he knows that usually the best seed produces the largest and most profitable crops.

Seed of a high quality gives the crop a good start. As a result, the crop is well established before weeds can grow; it is better able to withstand unfavorable conditions that may occur during the growing season; and it ripens before the fall frosts can harm it. In these and in other ways, a crop grown from good seed has a

These grain samples were obtained in a survey to find out the kind of seed that farmers were sowing. Left sample contains 5,840 weed seeds per pound. Note the weed seeds at the top. This sample is unfit for seeding. Right sample: Registered seed. It contained no weed seeds and germinated 100 per cent. (Saskatchewan Government photo)

very much better chance to do well than that produced from poor seed.

The farmer or gardener who sows poor seed is a gambler. Only exceptionally favorable conditions can produce strong plants from poor seed. Good seed is the only safe seed. Good soil deserves good seed.

It is not always safe to judge seed by its appearance. Plump, apparently well-formed seed often contains many dead seeds and may be unfit in other ways to sow. As you have already learned, it always pays to make sure of the quality of seed by testing it for germination before sowing it. Many farmers and gardeners test their grain and seed each spring. Testing should be done early, so that new seed may be obtained if the tested samples prove to be unsatisfactory. If a farmer does not wish to purchase new seed, he may sow more thickly to allow for the seeds that will not grow.

#### SOMETHING TO DO

Bring to the classroom, from home or a seed-store, samples of seed wheat, oats, or barley for the purpose of testing them for germination. Be sure to mix the grain in the bins thoroughly before you take the samples for testing. Why is this important? Also bring seeds of garden vegetables such as radishes, peas, or beans. You may test the seed grain and the garden seeds either by following the method described on page 357 or by using a rag-doll germinator. Remember that unless a seed sprouts strongly (both root and stem), it cannot be regarded as having germinated satisfactorily. Work carefully to ensure accurate results.

Registered seed grain in sacks ready for shipment to farmers. Attached to each sack is a government tag showing the variety of seed, the name of the grower, and other information. (Saskatchewan Government photo)

In case you find that the germinating strength of the seeds you test is not high, what should you do about it? What would a scientist do?

Many farmers prefer to sow *registered seed* because they know it is good seed. It is called registered seed because a record of its origin is kept by the Canadian Seed Growers' Association at Ottawa.

Registered seed is good seed because: (1) It is 99.99 per cent pure (one variety). (2) Only varieties that have proved to be desirable may be registered. (3) Before being harvested, it must be inspected by a

Two samples of wheat. Left: Small, shrunken, low-grade wheat. Right: Large, plump, high-grade wheat. Which would you select for seeding purposes? Give several reasons for your answer.

Dominion government inspector, who allows it to be registered only if he finds it to be pure and of high quality. (4) It must be properly cleaned, to remove all noxious weed seeds. (5) After the seed is cleaned, it must be sacked, and each individual sack inspected and sealed by a government inspector. The inspector must attach to each sack a tag on which is shown the variety and the grade, the name of the grower, and other information. (6) Before a sack is sealed, the seed must be tested for germination, weed seed content, and quality. First grade registered wheat, oats, barley, or rye must germinate at least 85 per cent.

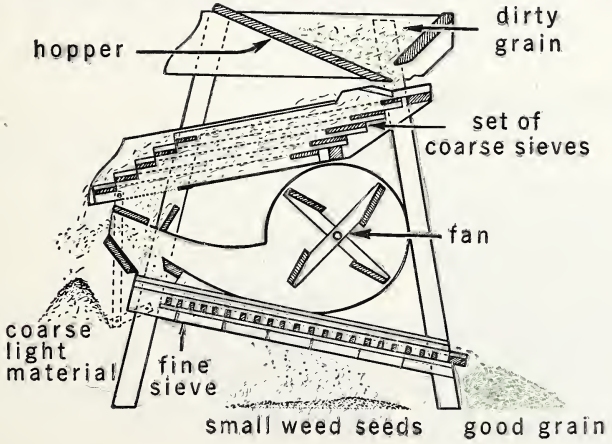
#### SOMETHING TO DO

If you live in a rural area, enlist the help of someone in the community, such as an agricultural representative, a 4-H Club leader, or a Junior Farmer member, and practise judging common grains, such as wheat, oats, and barley. Start with a group of three or four samples. Examine each lot carefully. Award your samples first, second, third, and fourth place. Write out your reasons for your placings, and have them checked afterward by the person who is coaching you.

If the opportunity is available, enter a grain-judging competition. At a fall fair examine prize-winning samples of grain.

#### TEST YOUR KNOWLEDGE AND UNDERSTANDING

1. State as many reasons as you can why the best seed available should be used to sow crops.
2. If you were selecting good wheat for seeding purposes, what qualities would you look for?




Most farmers find it necessary, at times, to remove weed seeds from their seed grain. This can be done by a machine called a *fanning mill,* such as the one shown above. Study carefully the diagram of the fanning mill at the left. Explain how weed seeds, cracked small light shrunken wheat, bunt balls, and other grains are removed from a sample of wheat in the process of cleaning. (Saskatchewan Government photo)

3. The appearance of seed is not always a safe guide to its value for seeding purposes. Why?

4. What is the value of a germination test? Describe one satisfactory method of making a test.

5. What reasons can you suggest for thoroughly cleaning seed?

### TEST ON THE SCIENTIFIC METHOD

1. In the experiment outlined on page 356, why was it necessary to use a number of seeds in each case rather than only one or two?

2. In parts 1, 2, 3, 4, and 5 of the experiment: (1) What conditions were the *same* for both lots of seed? (2) What condition was *varied* in each case? (3) Why must no more than one condition be varied in any one test? (4) Why was it necessary to use two lots of seeds in each part of the experiment?

3. Ted Smith wanted to know if both warmth and moisture are necessary for germination. First he put two beans in moist garden soil in a flower-pot and stood the pot on a window-sill where the sun could reach it. Then, he planted half a dozen corn grains in moist sawdust in a chalk box. He kept the box in a warm place in a dark corner of the cellar. Both lots of seeds were kept moist. After five days, Ted observed that all the beans and all but one of the corn grains had germinated. He concluded that warmth and moisture are necessary for germination.

(*a*) Was Ted justified in reaching this conclusion?

(*b*) Make a list of all the points about Ted's experiment that you consider were unscientific.

## SPRING GARDENING ACTIVITIES

In a review lesson on seeds, Miss Peterson's class recalled some of the important things that they had learned from their discussions and experiments about seeds. On the blackboard, Miss Peterson wrote the heading: *What We Have Learned About Seeds.* Then as different members of the class made suggestions, she listed them beneath the main heading. They started the list with the following statements:

— Seeds are adapted to grow into new plants.

— Each seed contains an embryo and a supply of food to nourish the embryo until it is fully germinated.

Altogether, more than a dozen noteworthy facts were mentioned. Miss Peterson expressed her pleasure

that her class had learned so many important ideas about seeds. She then raised the question: "Many other topics arise naturally out of our study of seeds. In which related topics are you interested?"

Sharon Kearns thought that it would be interesting to learn more about how breakfast foods are made from seeds.

Tom Blair suggested that the class compile an illustrated story that would tell what happens to wheat from the time it is harvested on a prairie farm until it is eaten in the form of bread in a large Ontario city.

"Tom's suggestion would be interesting," commented Anne Brooks, "but I think that it has more to do with the harvesting and marketing of crops. It's really a fall activity. As this is spring, I think we should select a spring project of some kind."

"That gives me an idea," said Mary McLean. "Now is the time of year when all the gardeners and farmers are getting ready for seeding. Let's make it a spring gardening project."

This idea was discussed at some length, and in the end it met with the approval of the majority of the class. They proceeded to plan the activity in some detail. As the time remaining for the study of seeds was rather short, they decided to limit their project to a vegetable garden. Possibly in the fall or next year they could study a flower garden. The pupils agreed that committees should be arranged to gather first-hand information from gardeners about spring gardening activities. It was suggested that seed catalogues, pamphlets, and books on gardening also would be helpful.

A number of topics were listed. Some pupils volunteered and others were appointed to obtain information about these topics and report back to the class. Each committee consisted of two or three members. The topics chosen were:

- Suitable location for a vegetable garden.
- Best kinds of soil.
- Preparation of the soil for seeding.
- Selection of the seed.
- Planting the garden.
- Care of the garden.
- Gardening tools.

It was agreed that the reports would be received in this order, and that reports were to be ready in a week's time.

### Where should a vegetable garden be located?

Edward Wentworth and John Thomson were the first to report.

Spring gardening activities. These boys and girls are planting a vegetable garden. (M. Kesterton photo)

Water from the farm dugout on the left is being used to water the garden on the right. Note the windbreak of trees on the extreme right that protects the young plants from strong winds. (P.F.R.A. photo)

Edward began their report in these words: "John and I decided to talk with Mr. Smith, a gardener who lives down the street from us. He always has a fine vegetable garden. Mr. Smith told us that to grow good vegetables, the garden must get plenty of sun. It's no use planting a garden in the shade of big trees. In the city, it's fine to have a garden in the back yard provided there isn't too much shade.

"On the farm, a good location would be near, but not too close, to a windbreak," continued John. "A windbreak will protect the plants from damage by strong winds. Also, we learned that the vegetable garden should be near the house. This makes it handy for the farmer's wife to get the vegetables for dinner.

"Another point that Mr. Smith mentioned was the need for good drainage. A garden should be located on well-drained land so that it can be seeded early in spring. Low-lying land is likely to be flooded in spring, which, of course, delays gardening operations. Also, poorly drained land may be flooded by heavy rains after the garden has been seeded. If this happens, the seeds and young plants may be smothered to death because the air supply is shut off."

**What soils are best for gardening?**

Joan Graham and Gail Oliver were to find out about the best kind of soil. They checked several pamphlets on gardening and learned that a deep rich loam is the ideal soil for a vegetable garden.

Clay soils are not very suitable for gardening. However, they can be improved by the addition of sand and well-rotted manure. These soils hold the moisture well, but in hot weather they bake and form a hard

crust on top. In wet weather they become very sticky and hard to work.

Sandy soils often contain only a small supply of humus and are lacking in fertility. Why do they not hold water very well? Sandy soils can be improved for gardening purposes by the addition of large amounts of well-rotted manure.

Very often the kind of crop to be grown determines whether or not a soil is suitable.

**How should the soil be prepared for seeding?**

Miss Peterson next called on Gary Morin and Charlie Hunt to tell the class what they had found out about getting the soil ready for seeding.

Gary commenced his report by saying: "The best way to prepare garden soil for planting depends on the kind of soil and also on the locality. Many gardeners prefer to have their gardens ploughed or spaded in fall. This gives the lumps a chance to mellow with the frosts of winter. It also permits earlier seeding in spring. Fertilizer, in the form of rotted manure or compost, should be thoroughly dug into and mixed with the soil."

"In spring preparation," Charlie added, "the garden soil should be thoroughly cultivated as soon as it is dry, to make a fine, loose, seed bed."

**What vegetables are best to grow?**

Lillian Barker and Marie Lucas told their classmates that they had looked in seed catalogues to find information on recommended varieties of carrots, beans, peas, and other garden crops. They also had asked their parents which varieties were the best. They learned that the best varieties to grow are not always the same for all parts of Canada. A variety that is excellent for Ontario may not be suitable for the prairie garden. Differences in soil and climate must be considered. It is very important, therefore, to choose varieties that have proven suitable for your district. Some varieties are especially developed for "quick freezing" for storage, and others for canning. Vegetables that are easy to grow are: *carrots, beets, radishes, onions, lettuce, peas, green beans, cabbages, turnips, tomatoes,* and *potatoes.* One should select crops to supply a succession of vegetables in spring, summer, and fall, and have others for storage for winter use.

As we have already learned, gardeners find it advisable to use only good quality seed that has been tested and found to have high germinating strength.

**Planting the garden**

*Planting the Garden* was Marie Lucas' and Lillian Barker's topic. They stated that they had visited several gardens and had asked the gardeners a number of questions. "We asked Mr. Jones when a garden should be planted," said Marie.

"He told us that he never puts all his vegetables in at one time. Some vegetables, such as onions, lettuce, carrots, beets, radishes, and peas, will

Many new mechanical aids are available to the gardener. This rototiller cultivates the soil much more quickly and with much less work than is required to dig and cultivate it by hand.

stand quite a little frost, so usually it is safe to seed them early. This will depend, of course, on the season. Other garden crops, such as potatoes, beans, cucumbers, squash, and corn, are easily damaged by frost. They should not be sown until danger of frost is over."

"Some of the gardeners with whom we talked," added Lillian, "start their tomato, cauliflower, and cabbage plants in shallow boxes or flats in their homes. Others start them in a hotbed or a coldframe. After all danger of frost is past, they transplant these plants to the garden. Cabbage, cauliflower, and celery will stand some frost, but tomatoes and melons are very tender, and a few degrees of frost will kill them.

"If the garden is small, it is not advisable to grow potatoes, squash, corn, or other vegetable crops that require a lot of space. Early maturing crops, such as onions, lettuce, and radishes, may be sown between the rows of late-maturing crops such as cabbages and parsnips. These early crops are used up before the later crops need the space."

"We next asked Mr. Jones how deep the seeds should be planted," continued Marie. "That depends on the size of seed, we learned. Small seeds such as lettuce should be planted only about one-half an inch deep, while larger seeds such as beans, peas, and corn are usually sown from two to two and a half inches deep. A general rule is to plant seeds at a depth equal to four times the diameter of the seeds."

Other information mentioned in the girls' report about sowing the vegetable garden, included the following facts:

Seeding should be done in fairly long rows. Rows of vegetable crops should be uniformly spaced. In drier areas it is advisable to space the rows farther apart. This gives each plant a greater area from which to gather moisture. In larger gardens, the rows should be far enough apart to permit the use of a motorized scuffler or cultivator to keep the soil loose and fine and to kill the weeds. In areas where the land is irrigated, gardeners

plan the direction of the rows so as to make irrigation easy.

When the seeds are sown in a small garden, it is a good idea to press down the soil over the row to bring the seeds in close contact with the moisture. This is an aid to uniform germination.

The girls concluded their report by stating: "It is better to have a small garden that is well cared for than a large one that is neglected."

### What gardening tools are needed?

Walter Forbes and Oliver Sereda reported to the class on gardening tools. "First of all," Walter said, "we went to look at machinery at an implement dealer's. The manager showed us the different types of *ploughs* that farmers use to plough their gardens and *rotary-tillers* and *wheel-hoes* that are often used to cultivate smaller garden plots."

"Next we dropped in at a hardware store. There we saw *shovels* and *spades* that are suitable for digging small gardens. Also there were *steel rakes* and several kinds of *hoes* that help the gardener to prepare the seed bed, to plant the seeds, and later to cultivate the soil to rid it of weeds."

"Oliver will tell you about the third call we made."

"Well, we decided that we would like to see some of these labor-saving tools being used in a garden," said Oliver. "So we rode our bikes out to the City Market Gardens. There we learned, first-hand, how machines such as hoes, wheel-hoes, hand seeders, and rotary-tillers were making the work of the gardeners easier and more enjoyable."

Miss Peterson observed that there was no time left in the science period to hear the rest of the reports, which would have to be held over until the next lesson. She suggested, also, that if any pupils had questions they wished to ask or comments they wished to make about any of the reports, they would have an opportunity to do so the following day.

### Caring for the garden

"*Care of the Garden after Planting,* was our topic," Joan Wilson informed the class in the next science period. "At this time of year, the daily newspapers usually print articles on gardening that are written by experts. We were lucky enough to find several timely articles in this week's papers. Also Iris found an excellent illustrated story about gardening in the April issue of a magazine."

A combined hand seeder and wheel-hoe. The seeder attachment is shown in place. It can be removed easily and the small plough (left front) or the cultivator teeth (left middle) fixed in place. (S. L. Allen and Co. photo)

A carefully tended vegetable garden. What vegetable crops can you identify? Successful gardening requires good soil, careful planning, good seed, and protection against insect enemies, plant diseases, and weeds. (Ontario Agricultural College photo)

Briefly, these are some of the things the girls learned about caring for a vegetable garden:

To begin with, the garden should be fenced. On farms, this is necessary to keep out farm animals, wild animals, and poultry.

It should be kept free from plant rubbish. A clean garden makes it easier to keep insect pests and plant diseases under control.

During prolonged dry weather, the garden should be thoroughly watered. A light sprinkling does no good. It is recommended that, where possible, a trench between alternate rows of vegetables be opened with a hoe and that water be allowed to run into the trench until the soil is wet to a depth of about twenty inches.

Small gardens should be cultivated frequently with the wheel-hoe, ordinary hoe, or Dutch hoe. For farm gardens and market gardens, a motorized cultivator (or horse-drawn scuffler) should be used a few days after a heavy rain or after irrigating. This will prevent a crust from forming on top and will also kill the weeds.

To hurry the growth of certain plants, commercial fertilizers can be added to the soil around them. In doing so, one must take great care to follow closely the directions that come with the fertilizer.

A close watch should be kept for the appearance of insect pests. Colorado potato beetles, cabbage butterflies, and cutworms are three common insect pests that molest vegetable gardens. See pages 419, 422, and 423. There are poisons available to control each of these.

Sometimes plant diseases damage garden crops. Damaged crops should be sprayed in order to ensure that diseases are kept in check.

Often garden crops such as carrots, beets, and parsnips are sown too thickly. If too crowded, the plants become weak-rooted and grow tall and spindly. It is necessary to thin them out at regular intervals by removing some of the surplus plants. To ensure healthy growth, the leaves of one plant should not overlap the leaves of the plants around it. Young beet plants that are pulled out make excellent "greens" for the dinner table. Tiny carrots are tender and delicious, too.

Side branches, or laterals, of tomato plants should be removed. The main stems should be "trained" up tall stakes to which they should be tied at about one-foot intervals.

Other members of the class were able to suggest additional things that should be kept in mind when caring for a garden.

At this experimental farm and others elsewhere, varieties of seeds of different kinds of crops are grown in separate plots in order that scientists may learn which are most suitable for the climate and soil conditions found in certain areas of Canada. (Regina Experimental Station photo)

**Of what value is a vegetable garden?**

The final report was brought in by Gordon Wayne and Tom Grant. Their topic dealt with *The Value of a Vegetable Garden.* It was intended to round out the study of spring gardening activities.

Gordon said that they had gone to a different source of information from those reported by the other committees. They had watched one television broadcast and listened to several radio programs. These broadcasts were by men and women who are known to be authorities on gardening.

"Fortunately for Tom and me," Gordon continued, "an outstanding Canadian gardener recently spoke over the radio on the topic: *What can you expect to get out of a garden?*

"Of course we all know that you expect to get fresh vegetables out of a garden. A variety of vegetables

from spring through to freeze-up time, available at your back door for the picking, is something to be desired. And usually there will be a good supply left over that can be stored for use in winter. As we have learned, fresh vegetables help to keep us healthy. All of us should eat them daily."

Tom went on to explain that the gardener to whom he had listened on the radio stressed other benefits that we sometimes overlook.

"Outdoor gardens provide activity in the sunshine and air. This also is an aid to healthful living. Exercise is good for us, and especially so if it is taken out-of-doors.

"Many people who get interested in gardening find in it an excellent form of recreation. They get keen enjoyment out of working with soil. They get satisfaction out of preparing a lovely warm bed for the tiny seeds. They plant the seeds hopefully. They watch closely from day to day for the little seedlings to push or pull their first leaves above the surface. They care for the plants by providing them with water when they are thirsty, and with protection when the wind blows strongly. They help them in their fight against their enemies — plant diseases, insect pests, and weeds. By providing these growing things with this needed care, the gardener helps greatly to improve the appearance of his neighborhood. This makes for better citizenship. Truly, gardening benefits man in many ways. Some people go to distant places in search of happiness; a gardener finds it by working in his own good soil."

**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

1. To be a success, a vegetable garden must be located where it will not be shaded from the sun. Explain.

2. What would be some disadvantages of having a farm garden located in a low spot about a quarter of a mile from the house?

3. (*a*) State some advantages of having the garden ploughed or dug in the fall.

(*b*) How does the soil benefit by digging into it a heavy application of well-rotted manure or compost?

(*c*) What cultivation of the soil is usually necessary in spring to provide a good seed bed?

(*d*) Name four common gardening tools and tell briefly what use a gardener makes of each.

4. (*a*) As you know, some vegetables are more easily grown than others. Mention ten vegetables that are easy to grow.

(*b*) How would you find out the best varieties of those vegetables to grow in your locality?

5. (*a*) Name five vegetables for which the seeds can safely be sown early in the spring.

(*b*) What vegetable crops should not be sown until danger of frost is past?

(*c*) Mention two vegetable crops that are often started in hotbeds or in coldframes.

6. Tell in your own words how a vegetable garden should be cared for after seeding, in order to get the best results.

7. Discuss the value of a vegetable garden from the standpoint of healthful, pleasant living.

## WHAT HAVE YOU LEARNED?

### IMPORTANT SCIENCE IDEAS AND UNDERSTANDINGS

A

1. One of the wonders of nature is that many plants, including the towering trees of the forest, the largest of living things, grow from tiny seeds.

2. A seed is fitted to grow into a new plant by having a young plant or embryo within it and also a food supply to nourish the young plant until the seed is fully germinated.

3. There are two main types of seeds — those that resemble the bean and those that resemble the corn.

4. Man makes use of the substances that plants store in their seeds in the form of starch, sugar, proteins, and oil.

5. In order to germinate, seeds require warmth, air, and moisture.

6. Seed grain, and often vegetable seeds as well, should be tested before seeding to make sure that they have high germinating strength.

7. Registered seed is safe seed for a farmer or gardener to sow.

8. Vegetable gardening is an aid to healthful living because it provides fresh vegetables for the table, the satisfaction that comes from watching them grow, and wholesome relaxation and exercise in the open air.

**(a) The foregoing sentences are all true statements of important science ideas and understandings. Read and discuss them carefully as a review of this chapter.**

(b) The following sentences describe situations in which some of the ideas expressed in A apply. To test your ability to apply ideas to actual situations, match sentences in A with situations in B to which they apply.

B

1. Miss Peterson's class examined some garden pea seeds and also some grains of wheat. They found that every pea seed contains two cotyledons but each wheat seed contains only one.

2. One day in spring, Mr. Brown was busy painting his house. He found that by adding linseed oil to the first or priming coat, the paint could be applied more easily and also that it covered a much larger area.

3. Mr. Jones was getting his front yard ready for a lawn. He cultivated the soil thoroughly and then watered it heavily with the sprinkler. A few days later he hoed out all the weeds that had germinated; then he raked the soil again. He repeated this process several times before finally sowing the lawn to grass.

4. Mr. Williams was preparing his seed grain for sowing. He knew that he could not tell by merely looking at his seed grain whether or not it would grow.

5. Working in her garden was a great pleasure for Mrs. Moore. She knew the truth of the saying "a gardener knows where to dig for happiness."

6. A well-known poet wrote these words: "Tall oaks from little acorns grow."

**IMPORTANT SCIENCE TERMS**

A

| | | | |
|---|---|---|---|
| embryo | cotyledon | endosperm | germination |
| registered seed | compost | plumule | grass family |
| drainage | germinating strength | cultivate | transplant |

To show that you understand and can use the science terms listed in A, match with the situations described in B those terms which apply.

B

1. Farmer Jones thought it wise to purchase seed wheat that was guaranteed to germinate at least 85 per cent.

2. When they split open a soaked bean, Joan and Marie found a part that looked like a small plant.

3. When a seed is provided with warmth, air, and moisture, a root soon emerges from the seed coat.

4. Tom Blair and his father used a spade, a hoe, and a steel rake to prepare their garden for planting.

5. Mrs. Kusior and Ruth started their tomato plants in a hotbed. After a number of weeks, when danger of spring frosts was past, they took the tomato plants out of the hotbed and planted them in the garden.

6. The pupils of Miss Peterson's class examined the leaves and stems of crested wheat grass, timothy, brome grass, wheat, oats, and barley. They found in every case that the leaves were long, narrow, and parallel-veined and that the stems were jointed.

7. When getting his garden ready for winter, a gardener sometimes makes a pile of dead plants and leaves along with several layers of soil. This pile is watered thoroughly on several occasions, and then is left so that the plant materials may rot.

**SCIENTIFIC METHOD AND ATTITUDES**

1. Mr. Brown wished to seed 200 acres to flax. Having no seed of his own, he bought some which he saw advertised. The variety was a highly recommended one; the seeds were large and plump. The price—$2.00 per bushel—seemed a little high, but as Mr. Brown was willing to pay extra for high quality seed, he purchased it.

The flax was seeded at the usual time, in well-prepared, rich, warm soil. Heavy rains supplied the required moisture. With prospects bright for a big crop, Mr. Brown decided to take a long-delayed holiday.

In mid-August, he returned to his farm with every expectation of finding a bumper crop awaiting the harvester. But to his dismay he found no flax growing in his fields. The seed had failed to germinate, and the farmer learned, three months too late to save him from heavy loss, that he had sown dead seed.

Examine Mr. Brown's method of selecting seed. What parts of his method were scientific, and wherein did he fail?

2. Mary Lucas was helping her mother plant their vegetable garden. It was Mary's job to make drills or little trenches for the seeds with a hoe. In which of the following circumstances would she be showing a scientific attitude?

(*a*) If she assumed that all seeds should be planted at the same depth and proceeded to make the drills for lettuce, carrots, and beans all the same depth.

(*b*) If she read the directions about the best depth to plant as printed on the backs of the seed packages and then followed these instructions.

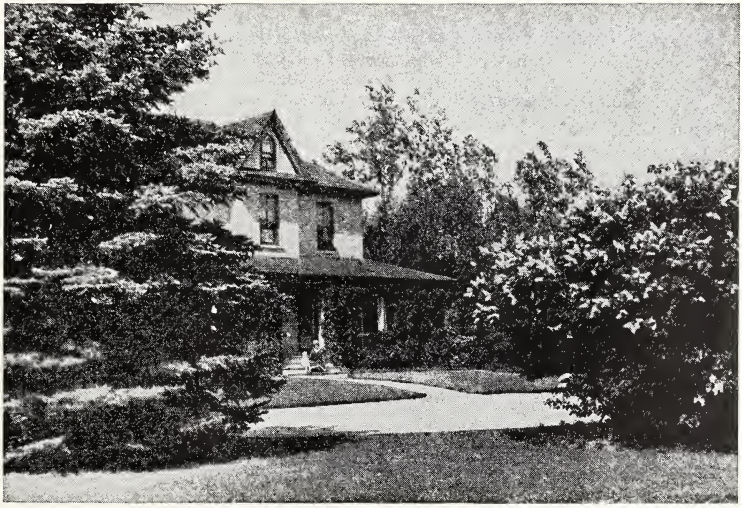
(*c*) If she decided on her own that it would not matter how deep the seeds were planted just so long as they were covered by soil.

(*d*) If she asked their neighbor, Mr. Smith, who is a skilful gardener, how deep she should make the drills for the different kinds of vegetables she was planting.

(*e*) If she consulted gardening pamphlets that are published by the Department of Agriculture and followed the suggestions given there.

(*f*) If she decided to plant the smaller seeds shallow and the larger seeds deep without consulting any authority as to the best depth to plant.

*Before and after*



Canadian Horticultural Council

*Who sows a field, or trains a flower,*
*Or plants a tree does more than all.*

CHAPTER 11

CHAPTER 11

# ATTRACTIVE SURROUNDINGS FOR BETTER LIVING

**The boy or girl whose home or school is set in surroundings of well-arranged trees, shrubs, green grass, and flowers enjoys privileges and conveniences denied to those whose homes and schools have no trees or hedges to check the wind, no green to soften the glare of the summer sun, and no flowers to radiate beauty and good cheer. What can you do to make your home and school grounds more beautiful? How do you celebrate Arbor Day in your school?**

According to a famous doctor, no man is really happy or healthy without a hobby. Gardening is one of the most satisfying hobbies. It can provide interest and enjoyment for people of all ages. The planning, planting, and tending of a garden involve pleasant mental and physical activity, and produce results that bring deep satisfaction to the gardener. There are few more enriching experiences than tending a garden as it develops in beauty and usefulness.

Besides being valuable to the individual, gardening offers you an opportunity to use science to provide beauty that you can share with others. You can invite friends to come into your garden to enjoy its color and fragrance, or you can carry its beauty to them in the form of bouquets. Gardeners work together, sharing knowledge and exchanging plants and seeds. A well-managed garden helps to make your community a better place to live in.

## LANDSCAPING THE HOME GROUNDS

Any house may be a dwelling; well-kept grounds help to make it a home.

The average home grounds fall naturally into three divisions: the front yard, the back yard, and the connecting side yard. The front yard is the public area. Its spacious open lawn, with a few well-placed shapely trees and shrubs, forms a fitting setting for the home. The back yard is a private area, a kind of *outdoor living-room*, where the family may assemble and enjoy themselves in summer, as they do in the inside living-room in winter.

Your outdoor living-room will have for a carpet the rich green turf, for walls and ceiling the blue sky itself. All the colors of the rainbow will be represented in the decorations, which will consist of carefully arranged borders of flowering plants and shrubs, and, if space and means permit, a lily pool, a rock-garden, and running water. The furnishings should include a few comfortable chairs, a table or two, and perhaps a bird bath, and for small children, play facilities, such as a sand-box, teeter, or swing.

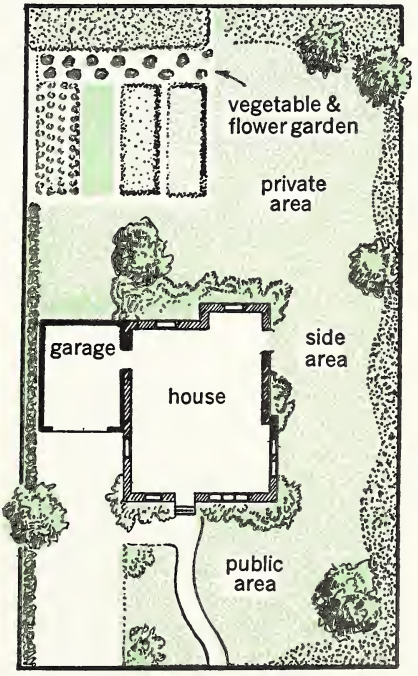
Your grounds, no matter how small, may be arranged on either a *formal* or an *informal* plan. In the formal style, everything is placed according to a definite geometric pattern. The informal grounds, though they should conform to a plan, are easier for the beginner to arrange. Trees and shrubs are planted in clumps, just as they are found in nature. Flowers are grouped in masses in irregular-shaped beds with gracefully curving edges.

#### SOMETHING TO DO

Work with your parents in making an outdoor living-room for your home. If this is not possible, you should at least plan a small garden of your own.

### A foundation of good soil is necessary

If you are planning to establish a beautiful outdoor living-room of




A simple plan for the home grounds. Notice the three areas and the general arrangement of the trees, shrubs, and flower-beds.

which you will be proud, your first consideration must be good soil. It is useless to put much work into a garden and to buy good seeds or plants, if the soil is poor. As you know, there is a great difference in soils. Plants will thrive in some soils, while other soils must be greatly improved before good results can be expected.

#### SOMETHING TO DO

Examine the soils in your locality. Make a collection of different kinds. Gather soils of different colors — black, brown, red, grey; soils of different textures — coarse, loose, and sandy; fine, sticky, and clayey.

### There are many kinds of soil

Sandy Soils. — Sandy soils contain a large amount of *sand* (coarsely pulverized rock), a small amount of *clay* (very finely pulverized rock), and usually only a small supply of *humus* (decayed plant and animal material). They are coarse and loose and do not hold water very well.

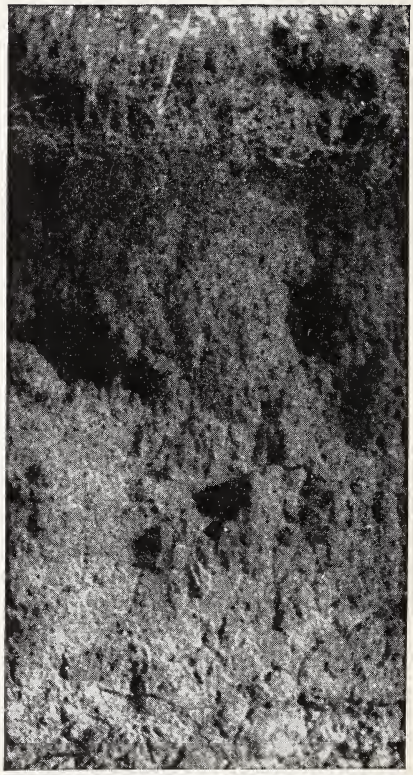
Clay Soils. — Clay soils are composed mostly of clay with little sand. They are called "heavy," because they are sticky and hard to cultivate. Clay holds water well, and, after a rain, bakes on top, forming a hard crust.

Loam Soils. — Loam soils are composed of various amounts of sand and clay. They are well supplied with humus and are usually very satisfactory soils for most crops. Loam soils are dark in color and moderately easy to work. They have good water-holding power.

You will easily understand that you cannot regard all soils as the same and that you must treat each kind differently to obtain the best results.

### Some soils are lacking in humus

A soil that does not contain a good supply of humus is like a plate with



All soil is not the same. Note at the top the black soil, rich in decayed plant material. The grey soil below is lacking in plant material and will not be as good for growing plants as the top soil. (Soil Department, University of Saskatchewan photo)

Before a beautiful lawn and shrubs, such as we see in this photo, can be grown, a foundation of good, well-prepared soil is required. It is easier and more satisfactory to establish this foundation of good soil *before* setting out the plants rather than afterwards. (Portland Cement Association photo)

little or no food on it. As you know, plants secure from the soil many of the food materials that they require. A large part of this food supply is in the humus.

A good gardener studies his soil. If it is lacking in humus or fertility, it may be improved as follows:

1. By adding ***barnyard manure.*** Manure provides *nitrogen, phosphorus,* and *potassium.* All of these are important plant food materials. In addition, *manure adds plant material to the soil.* The plant material acts as a sponge and improves the water-holding capacity of the soil; it also has other beneficial effects. Usually, only well-rotted manure should be added to the soil to avoid sowing live weed seeds that may be in it. In the garden, manure should be dug into the soil well in advance of the time of seeding.

2. By applying ***commercial fertilizers.*** *Ammonium phosphate* will supply nitrogen and phosphorus. *Ammonium sulphate* provides nitrogen, but in a form more slowly useable by plants. Other substances used as fertilizers are *bone meal* and certain *by-products of meat packing houses.* These do not supply humus.

3. By maintaining a ***compost heap.*** An excellent supply of organic matter for the garden soil may be prepared by piling waste *stems* and *leaves,* and *grass clippings* (if removed from the lawn) in layers, six or eight inches deep, alternated with one or two inches of soil. If the heap is kept moist and forked over once or twice in the fall and again early in the spring, the plant material in it will readily decay. The pile will be more likely to remain damp if the top is flat and the sides are perpendicular. In the spring, the compost heap can be spread over the garden like manure and thoroughly spaded into the soil. Diseased plants or weeds bearing ripe seeds should not be thrown on the pile. Why?

4. By buying ***new soil.*** The soil around your home or school may be clay subsoil from the basement, which will not be good for plants. Or it may be that the soil in your garden has been used for so long that the humus originally in it has been almost exhausted. If this is so, the best way to improve it may be to *buy good topsoil,* rich in humus, to spread over the poor soil. Good soil may be secured in a gully or in the woods, where the leaves of the trees have built up a rich supply of humus over a period of many years.

5. By ***green manuring.*** Many gardeners and farmers add humus to their soil by sowing a quick-growing crop, such as rye or clover, then ploughing it into the soil.

### Thorough cultivation is necessary

Success in gardening depends to a large extent upon how well the soil is cultivated, both before and after the crop is sown. Cultivation admits air to the soil, opens the soil so that water may enter, destroys weeds, and pulverizes the soil to make a good seed bed. Find out from gardeners the best time and method of cultivating the soil in your locality.

## A good lawn is essential

The lawn is one of the most important features of well-kept grounds,

A cool, green lawn provides a beautiful foreground for the trees and shrubs around this home. (Ontario Agricultural College photo)

because its rich green tone forms the setting for buildings, trees, flowerbeds, and borders. On hot summer days, its soft, cool surface offers an ideal place to rest or play.

The best way to find out how a good lawn can be established is to talk to gardeners who have good lawns. They will be delighted to assist you if you show them that you are interested.

#### SOMETHING TO DO

With a group of fellow pupils, or alone, interview the owners of some of the best lawns in the community and obtain detailed information about the way the lawns were made and how they are being maintained. Report your findings to the class. Check the information that you have gathered with the suggestions for lawn-building given in the paragraphs that follow.

### Building a new lawn

PREPARING THE SOIL. — The soil for a new lawn should be carefully cultivated (spaded or ploughed) several weeks in advance of the time of seeding. If it is too clayey or lacking in humus, a good supply of well-rotted manure or compost should be dug into it. It is often a good plan to spread a few inches of rich topsoil over the area to be seeded. The surface must be carefully raked to make it level and fine, and it should also be well rolled. It should be kept moist so that weed seeds will grow; once grown, they can be destroyed.

SOWING THE SEED. — Kentucky blue grass and Canadian blue grass are good lawn grasses. Many people like to have some White Dutch clover in their lawns. In drier areas, Fairway crested wheat grass is good. Visit a seed store to find out what seed mixture is best suited to your climate and soil.

The seed should be broadcast over the surface of the soil, first lengthwise, then crosswise. The soil may then be very lightly raked and should be rolled to press the soil around the small grass seeds.

CARING FOR THE NEW LAWN AFTER SEEDING. — While the seed is germinating, the surface of the soil must be kept *constantly moist*. A fine, gentle spray for watering is important to avoid washing out the fine seeds or tiny new grass plants. Moisture is necessary both for the germination of the seed and to prevent the formation of a crust on the surface of the soil. If a crust forms, it will curl up and pull out many young grass plants, thus causing bare spots in the new lawn.

When annual weeds appear in a newly seeded lawn, they will be controlled by being cut when the grass is cut. Perennial weeds, such as dandelions, plantain, and chickweed may be pulled out. However, the pulling should not be attempted too soon, or patches of grass will also be torn out. A weed killer, such as 2,4-D, will later control dandelions and many other weeds. There is now no excuse for having dandelions in a lawn. An effective weed killer for crabgrass is also available.

The foundation planting on each side of this doorway links the house and grounds together into a single attractive scene.

When the new grass is 2 to 3 inches tall, but not before, cutting should be started. It should be continued at intervals, as necessary, so that the lawn will always look well-kept. Avoid cutting the grass closer than 1 or 1½ inches. If the grass clippings are well scattered, it is best to leave them on the lawn.

At freeze-up, a thin covering of well-rotted manure may be spread over the lawn. It should be raked off in the spring, and the finer parts should be worked in among the grass plants. Some gardeners like to add fertilizer to their lawns in the early fall. Others add fertilizer in the spring and give the lawn a light rolling.

If an abundant supply of water is available, water the lawn generously, as it will benefit from the application of plenty of water. Thoroughly soaking one part at a time is better than lightly sprinkling the surface of a wide area.

### Repairing an old lawn

It is possible to maintain a lawn in top condition for many years. Sometimes, however, bare spots develop or the grass becomes thin. When this happens, weeds should first be destroyed by using 2,4-D. Then the soil should be lightly cultivated to loosen it. Seed should be sown, raked into the soil, and lightly rolled. Low

spots should be filled in over a period of time by adding a thin layer of soil about once a week. These spots should be kept well watered.

Care following improvements to a lawn should be the same as that given to a new lawn.

### Planning a garden

To obtain the most satisfactory results from your garden, you should always plant to a plan. The plan should show where evergreens and other trees, as well as shrubs, flowerbeds, and lawns are to be planted. It should be made well in advance of the actual planting.

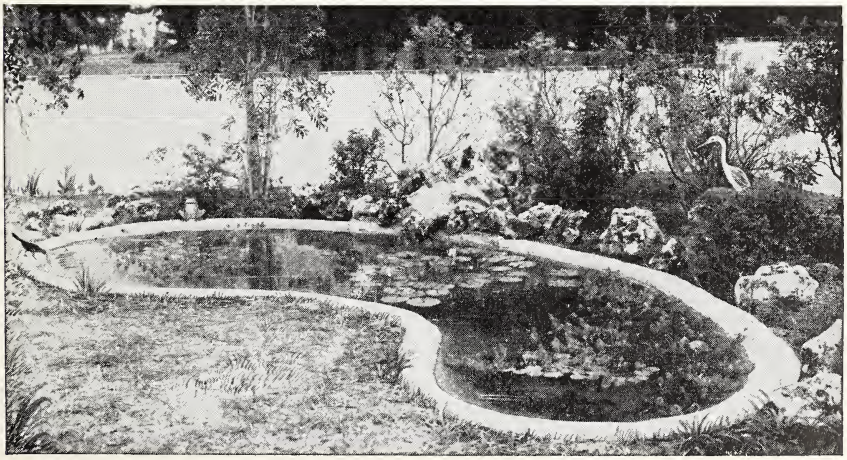
One of the wonderful things about planning a garden is that there are so many ways of arranging flowerbeds, borders, trees, and shrubs to produce a colorful and beautiful effect. No two gardens were ever alike.

### Foundation planting

Some people do not plant many shrubs close to the house. They prefer to place a few here and there, and to depend upon beds of flowers to produce the effect they wish. Other people like to produce a contrasting background or *foundation* of green shrubbery as a frame for the bright colors of their annuals and perennials. A foundation of shrubs and evergreens also helps to fit the house into the surrounding landscape.

Taller kinds of shrubs should be placed in the background. If windows are low, large plants should not be planted directly in front of them. It

A lily pool adds beauty and interest to a garden. It may be a home for goldfish and several kinds of attractive plants. Note, too, the decorations placed around this pool. (Portland Cement Association photo)



is important to provide for an increase in size. Small shrubs very soon grow.

Small native *evergreens,* such as *spruce, pine,* and *cedar* make suitable material to be transplanted for foundation purposes. Choose as perfect specimens as possible and place them where they will be seen to good advantage. From a nursery you may obtain *blue spruce, Scotch pine, cedar,* and other varieties which are good for certain locations. Flowering *shrubs,* such as *honeysuckle* and *lilacs* are suitable taller varieties. Attractive for the front of your foundation planting are smaller shrubs, such as *spirea, cotoneaster, forsythia, roses, Japanese barberry,* and others.

Consult a nursery man or catalogue for information regarding evergreens and shrubs that are hardy and otherwise suitable for your locality.

Careful planning of the foundation planting is particularly important.

#### SOMETHING TO DO

After securing sufficient reliable information by reading, visiting gardens, and talking with skilled and experienced gardeners, draw a garden plan suitable for your locality.

Show in your drawing (1) the *overall plan* of your garden, and (2) the *foundation planting* of green background that you think is required to set off effectively the flower-beds and lawns.

#### TEST YOUR KNOWLEDGE AND UNDERSTANDING

1. What reasons can you give in favor of landscaping the grounds around your home?
2. Why must your garden soil contain a good supply of humus? State several ways of increasing the supply of humus.
3. Why is it necessary for the soil to be thoroughly cultivated before and after the crop is sown?
4. Give an example to show that careful planning contributes to the success of your landscaping and gardening activities.
5. Briefly describe the purpose of foundation planting.
6. Describe the arrangement of evergreens and shrubs used in foundation planting. In your answer, name several trees and flowering shrubs that are suitable for foundation planting.

## GROW YOUR OWN PLANTS

Many of the flowering plants for your garden must be started early indoors to have them in bloom outdoors before the summer is too far advanced.

Raising your own bedding plants to transplant into your garden is more interesting than buying them, and is also less expensive.

**SOMETHING TO DO**

Start this year to raise such easily grown flowers as *stocks, pinks, marigolds, phlox, zinnias, sweet alyssum, salpiglossis,* and *cosmos.*

Later, you will become familiar with other suitable varieties that you will enjoy having in your garden. Try also to grow small seeded plants, such as *snapdragons, petunias,* and *pansies,* even though you may not find them quite so easy.

Plan your garden. Consult a seed catalogue to help you to decide what varieties to grow. Carefully consider the color and size of the varieties that you select.

Pansies are popular flowers. If they are planted in August and protected during the winter with leaves or straw, they will flower early in the spring.

### How to grow your bedding plants

Wooden boxes of convenient size, about 2½ or 3 inches deep, are necessary. A number of holes must be bored in the bottoms for drainage. The best soil is a sandy loam in which some fine, well-decayed manure has been thoroughly mixed. Sift the soil to remove coarse lumps and fibre. A suitable sifter can be made by tacking metal screening over a shallow box from which the bottom has been removed. Put enough of the prepared loam into your seed box to fill it within ¾ of an inch from the top. Press the loam lightly with a board or other flat surface to make it fairly compact. The soil should be moist but not wet. If the soil is too wet and is packed, it becomes too firm.

Your seeds may be some that you saved from your garden, or you may buy seeds from a reliable seed firm. Planting should be done between March 15 and April 10. Sow your seeds carefully and not too thickly. Cover them lightly by sifting soil over them. Care should be taken not to cover the seeds too deeply; the smaller they are, the shallower the planting should be. A good general rule is to plant at a depth of about four times the diameter of the seeds. The very small seeds should be barely covered with fine soil. Water them well, using a very fine sprinkler if possible, and keep the soil moist with daily sprinkling. To avoid washing out your seeds, it is a good plan to cover the soil with a cotton cloth, and to sprinkle or pour the water gently on top of the cloth. Place the box in

Zinnias and cosmos are popular annual flowers that will give plenty of color to your summer and fall garden. These plants can be started in hotbeds or coldframes. Because of their height, cosmos should be planted at the back of your flower garden. (George Keith and Sons photos)

a window or hotbed where it will be warm. (On page 392 you will find instructions on how to construct a hotbed.) Remove the cloth as soon as the seeds are well germinated.

Some gardeners prefer to start their plants in flower-pots, which they keep covered with a sheet of glass. In effect, a glass cover makes the flower-pot a small coldframe (see page 393).

A glass cover or several thicknesses of newspaper placed over your box will help to prevent the soil from drying out. This covering should be removed as soon as the young plants appear at the surface of the soil.

When the young seedlings have their second pair of leaves fully developed, they should be transplanted into a larger, deeper box or into a hotbed (see page 392). Fill the box with moist, well-prepared loam. Using a round stick, about 6 inches long and somewhat pointed, make holes in the soil in rows about 2 inches apart, and drop the small seedlings into them. Cover the roots by lightly pressing the soil *toward* them with your fingers. Be careful not to bruise the tender stems. Water the plants thoroughly at once. Watering will settle the soil about the roots and help them to become established more quickly under the new conditions. The purpose of transplanting is to develop a strong root system on each plant and to provide more room for sturdy and vigorous growth.

Even a few annual flowering plants will help to add color to your school grounds. Here two girls are setting out some annuals around a small shrub in a corner of their school grounds.

Now place the box in a hotbed, or in a coldframe if the weather is not too cold. Shade the box from strong sunlight for three or four days by covering the under-side of the glass with a window-cleaning preparation that dries and leaves the pane white.

The soil should be kept moist by watering it thoroughly each morning. Never sprinkle the plants in the hot sun.

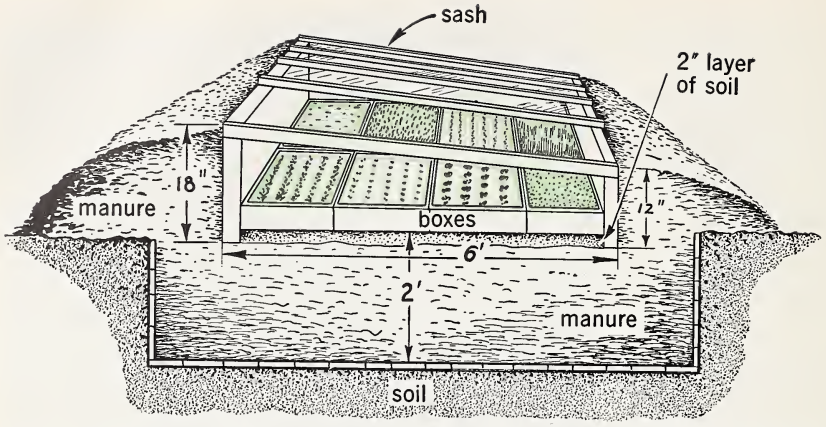
When your plants are from 2 to 3 inches high, it is time to begin *hardening* them for planting out. If the weather is warm, remove the sash, and allow the plants to get the direct sunlight for a part of each day. At first, expose them for only half an hour, and gradually increase the length of exposure from day to day. It is better to expose plants to the sun during the morning or late afternoon rather than during the hottest part of the day. Your plants should be hardy and strong by the end of May.

Transplanting into a permanent position in the garden should be done about June 1. An evening or a cloudy day is the best time. When lifting the plants for transplanting, as much soil as possible should be kept around the roots. Be careful not to let the roots dry out. Spread the roots out and cover them with soil. The garden should then be well watered to make the soil more compact and to work it in around the roots.

Your plants will continue to require attention and care for the rest of the season. Water and cultivate the soil as often as is necessary to keep it moist, free from weeds, and loose enough for roots to grow readily.

### Hotbeds and coldframes

If you wish to bring many flowers to maturity early in the season, you should have a hotbed. Choose a site for it that is exposed to as much sunlight as possible and that is at the




A plan for a hotbed. How is heat provided? What precautions are necessary to ensure success?

same time protected from cold winds. You may build the hotbed either on top of the ground or partly below the surface. If you wish to set it into the ground, you must begin your preparations the previous fall by digging a hole about 18 inches deep and about 3 feet wider and longer than the frame.

Use fresh horse manure as the source of heat. Pile the manure near the site you have chosen for the hotbed, and allow it to stand until it begins to heat. Then fork the pile over to ensure more uniform heating. Five or six days after turning, the manure is ready for the hotbed. Place from 1 to 2½ feet of manure in the pit, in layers; thoroughly tramp each layer. The quantity of manure depends upon the time at which the hotbed is prepared, less manure being required for a start late in March than for an earlier beginning. Then set the frame in place, bank more manure around the outside, and cover the manure inside the frame with a layer of about 6 inches of rich, sandy soil.

When the sash is in place, you will require a few days to regulate the temperature before sowing the seed. Keep the temperature between 68 degrees and 90 degrees Fahrenheit, by raising or lowering the sash as necessary. When you have regulated the heat to your satisfaction, stir up the soil, make the surface fine and level, and sow your seeds.

To grow plants successfully in a hotbed, you must provide adequate ventilation, light, moisture, heat, and protection from cold winds. To prevent *damping off* (a disease that rots plants at the ground level), plants must be very carefully protected from chilling draughts, and should not be watered too heavily. Ventilation may be controlled by raising and lowering

the sash. As the warmer weather approaches, the sash may be raised for longer periods each day in order to harden the plants for transplanting to the garden.

A *coldframe* is similar to a hotbed, but no manure is required. You can make a coldframe in a few minutes by nailing four 1-inch boards together in the form of a rectangular box and covering the top with storm windows. Some gardeners prefer to cover their coldframes with factory cotton instead of glass. The cotton is tacked to a light wooden frame so that it can be raised to allow for watering the plants and controlling the temperature. On cold nights, the frame may be kept warm by throwing a rug over it, or, if it is placed near a basement window, by suspending in it an extension electric light. Unless some such means for providing heat is possible, a coldframe cannot be used as early in the spring as a hotbed.

#### SOMETHING TO DO

Try growing plants in a coldframe. Although they cannot be started as early as in a hotbed, they will be ready for transplanting to your garden earlier than if they were grown in the open.

### Sow some annuals directly in your garden

Though much earlier bloom can be obtained from many annuals by starting them in boxes in the house or in a hotbed, excellent results can be secured by planting the seeds of other annuals in the garden. In fact, some annuals, such as *sweet peas, poppies, clarkia, candytuft, nasturtiums, bachelor's buttons, morning glories,* and *scarlet runner beans,* grow best from seeds sown directly in the garden. Sow seeds of annuals in the garden as early in the spring as possible, usually about the first week in May. Follow the directions given for sowing seeds indoors; you may also find some helpful hints in the directions printed on the seed packet.

### Hardy perennials for beds and borders

While annuals must be grown from seed each year, perennials, once established, produce their blooms year after year. They are easy to grow, and they supply us with some of our prettiest flowers. Early flowers, and therefore a long period of bloom, can be secured with a few well-selected varieties, attractively placed.

Varieties which are able to withstand the severity of cold winters are called *hardy.* Some common hardy perennials are: *peony, iris, bleeding heart, delphinium, columbine, golden glow, daisy, oriental and Iceland poppy, baby's breath,* and *chrysanthemum.*

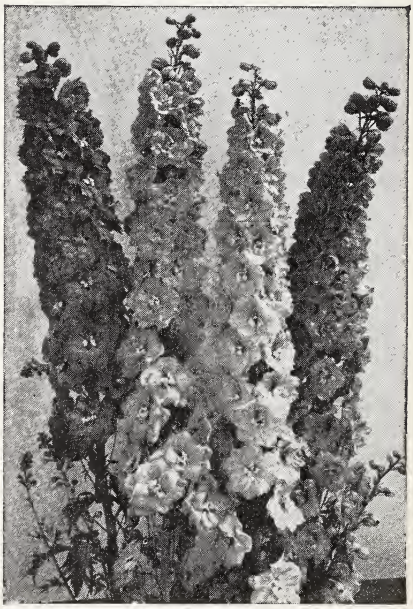
Perennials may be grown close to buildings (to hide basement walls) or in beds along walks and drives. An ideal location is at the border of the lawn against a background of shrubbery. The plants should be sheltered from high winds, as some of them, the delphiniums for instance, grow to a height of six or seven feet. The size of the bed will, of course, depend

Oriental poppies will add rich color to your perennial flower garden. (*Better Homes and Gardens* photo)

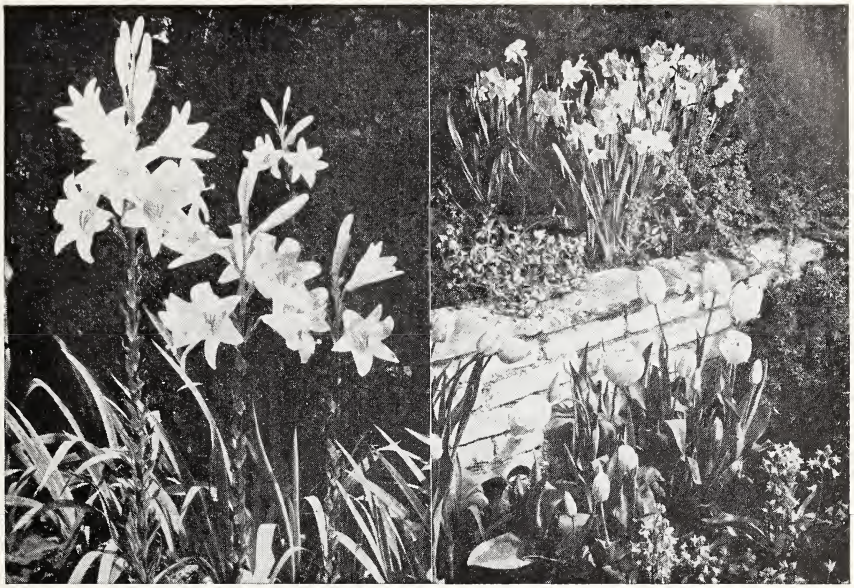
upon the number of plants to be grown. If several varieties are to be planted, the bed should be at least 6 feet wide. The soil should be a rich, deep, well-drained loam, with which plenty of well-rotted manure has been thoroughly mixed.

In selecting perennials, keep in mind (1) the time of flowering, (2) the color, (3) the height of the mature plants. Provide for a succession of bloom. In planting, mass the plants of each kind in clumps. If space is limited, use fewer varieties, and group them in large, irregular clumps. Strive for color harmony. Place tall plants, such as delphinium and golden glow, at the back of the bed; those of medium height, such as peony and columbine, in the middle; and low-growing forms, such as pinks, toward the front. Keep in mind the size of the mature plants. Peonies, for example, being large, spreading plants, should be placed about four feet apart, while pinks may be planted at intervals of less than a foot.

The soil around the perennials requires some cultivation. After freeze-up, for winter protection, the beds should be covered with straw manure, which should be left on in the spring until the period of alternate thawing and freezing is past. The manure can then be worked into the soil.



Delphiniums are available in a variety of colors. They are showy in the garden and beautiful as cut flowers. (Waller Flowerseed Company photo)



Lilies (left) and flowering bulbs (right) should be included in your perennial garden. Not all lilies grow well in all areas. Among the bulbs, tulips do well under a wide variety of climatic conditions. (*Better Homes and Gardens* photos)

### Bulbs

Another group of flowering plants that does not require re-planting each year is the *bulb family,* which includes *tulips, daffodils, narcissi, crocuses, snowdrops,* and *lilies.* Of these, tulips and daffodils are the most popular and easily grown, and should be included in your garden plan.

Most bulbs bloom early in the spring. Snowdrops appear before the snow disappears, and are followed in order by crocuses, daffodils, and tulips. Bulbs may be used to lend color to your perennial garden, or may be grown in your annual flower garden, because the flowers will mature and the leaves will die down by the time your annuals are ready to be transplanted outdoors.

Bulbs should be planted in early fall in well-drained soil rich in plant food and humus. The correct depth of planting is about three times the diameter of the bulbs. They show up best when planted in groups of from 4 to 10, with only one color in each group. Within each group, keep the bulbs 3 to 5 inches apart, and plant them all at the same depth.

Because they are low-growing, the early blooming snowdrops and crocuses belong near the front of the garden, or may be planted in the

lawn. Lilies, on the other hand, are taller and should be planted near the back of the flower garden.

Bulbs should be left in the ground from year to year. About every third year they may be dug up, separated, and planted again.

### Roses

Many people think that no garden is complete without roses, the most popular of all flowers. There are so many types and colors of roses that it is possible to find some suited to almost any garden. Is there a place in your garden for a trellis with climbing roses? If your area is not too cold and dry for hybrid tea roses, these plants will give you beautiful flowers from June until fall.

## Growing plants at school

By organizing "clean-up campaigns" and "planting bees" in the spring, you can do much to make your school more attractive. The appearance of your school, as well as of your home, will be greatly improved if the building is set among trees and shrubs and is enhanced by colorful flower-beds or window-boxes.

#### SOMETHING TO DO

1. Discuss with your teacher and classmates improvements that might be made in the appearance of your school grounds. Keep in mind the following suggestions:

(*a*) Do not attempt too much at once. A small garden, well cared for, is better than a large, neglected one. Even a few easily grown and showy annuals or perennials will add much to the attractiveness of your school yard.

(*b*) If your school is in a rural area, your garden plot should be fenced to protect it from livestock.

(*c*) Protection from the wind is essential in some areas. If your school is not surrounded by a wind-break, choose a corner or side of the school which you think will afford at least some protection from the wind.

(*d*) Work carefully, and when your plants have once started to grow, give them regular attention. *It is important*

What a difference there is between the appearance of the school in the photograph above and the school at the left. Trees and shrubs around the lower school improve its appearance greatly. (Top, Dominion Forestry Service photo; bottom, North Battleford School Unit photo)

Thorough cultivation of the soil will help your garden plants to grow. These pupils are making sure that no weeds rob their perennials of needed food and moisture.

*to see that arrangements are made to have the garden cared for during the summer vacation.*

2. If it is impossible for your school garden to be given much attention during the vacation period, plant perennials; they require less care than many other kinds of plants. Bring surplus plants from your perennial borders at home, and establish them in a well-prepared bed at school. You may not have many blooms the first season, but, when the plants are once established, a succession of color should amply reward you for your interest and work. You can enjoy the flowers of the bleeding heart, columbine, iris, and peony during the month of June, and of the golden glow, Iceland poppy, chrysanthemum, and several other varieties in September.

Select your perennials from the chart of suitable plants at the top of page 398, or from a flower catalogue. Keep in mind *color* and *height,* and plan for a *succession of bloom.*

3. Draw, to scale, a plan of attractive, well-arranged school grounds. Show clearly the location and arrangement of the school and other buildings, lawns, shelter belt, shade and ornamental trees and shrubs, perennial or annual flower gardens, play areas, several bird houses and possibly a bird bath and a comfortable seat or two in shady and protected places.

4. Visit other schools. Observe attractive homes in your locality. What methods have been used to give these places their pleasing appearance?

5. Discuss various plans for home and school improvement. Decide on one that suits your school or home. Estimate the labor and cost required to put your plan into effect.

**SOME HARDY PERENNIALS SUITABLE FOR YOUR GARDEN**

| Common Name | Color | Height | Period of Bloom |
|---|---|---|---|
| Pinks | assorted | 6 to 12 in. | July - August |
| Iceland Poppy | white, yellows | 1 ft. | May - September |
| Columbine | assorted | 1½ ft. | May - June |
| Blanket-Flower (Gaillardia) | yellow | 1½ ft. | July - August |
| Iris | various | 1½ to 2 ft. | May - June |
| Bleeding Heart | pink | 2 to 3 ft. | May - June |
| Shasta Daisy | white | 2 ft. | July |
| Baby's Breath | white | 2 ft. | July - August |
| Peony | assorted | 2 to 2½ ft. | June |
| Oriental Poppy | scarlet | 2 to 3 ft. | June - July |
| Golden Glow | yellow | 5 to 6 ft. | August - September |
| Delphinium | blues, etc. | 5 to 7 ft. | July - August |
| Chrysanthemum | various | ½ to 3 ft. | August - October |
| Painted Daisy (Pyrethrum) | white, pink | 1½ ft. | June - July |
| Iceland Poppy | white, yellows | 1 ft. | May - September |
| Tulips | various | 1 ft. | May |
| Daffodils | yellow | 1 ft. | May |

**Plant a window-box for your home or school**

A box filled with a mass of green foliage and brightened with the bloom of geraniums, petunias, and alyssum makes even the drabbest window attractive. Since a window-box is simply an intensive form of gardening, where a small space supports perhaps ten times as much growth as a similar area in the garden, the soil in it must be very rich.

Start the box indoors, if possible, and set it outside after danger of frost is past. As the box will be exposed to the air on all sides,

Although this is not a modern school building, carefully planned and well-cared for window-boxes do a great deal to give it an attractive appearance. (Ontario Agricultural College photo)

evaporation will consequently be very rapid; the box should therefore be watered well almost every day. If school window-boxes are not taken to someone's home during the holidays, arrangements must be made to have them watered regularly.

#### SOMETHING TO DO

*Make yourself a window-box, or join with another pupil in making one for your school.* — Window-boxes should be as long as the inside measurement of the window-sill, about 8 inches wide, and at least 7 inches deep. Use 1-inch thick boards. If you wish, reinforce the corners of the box with iron straps, placed on the inside, if possible, for the sake of appearance. Brace the sides of your box against possible spreading, by stretching a wire (or two wires if the box is long) between the sides. Thread the wire through two small holes near the top of each side. Bore a number of holes in the bottom of the box, and put some cinders, coarse gravel, or well-rotted manure in the bottom to provide drainage. Fasten the box securely to the window-frame, or support it on brackets below the frame. Stain or paint it to match the other woodwork. Fill it with soil to within 1 inch of the top, making sure that your soil is very rich.

In *planting the box,* you should place the taller-growing plants, such as *petunias* and *geraniums,* near the back and toward the centre. Trailing plants, such as *German ivy, trailing nasturtiums,* and *ice plant,* are placed toward the front. *Lobelia* is always a favorite for edging, but *alyssum* is easier to grow. All these plants are crowded much closer together than in the open garden. A *dracena* or some other fairly tall plant placed in the centre is very effective and adds variety to the box.

Water your window-box daily, and remove all the withered flowers before seed is formed.

#### TEST YOUR KNOWLEDGE AND UNDERSTANDING

1. Tell, in your own words, how to grow bedding plants for early bloom. Arrange your answer under the following headings: (1) Preparation of the soil and container, (2) Kinds of plants to grow, (3) Planting, (4) Care after planting.

2. Make a cross-section drawing of a hotbed. What is its use? What is the difference between a hotbed and a coldframe?

3. Name five annuals that can be successfully grown by planting the seed directly in the garden. When should the seed be planted?

4. What is meant by the term *perennial* as applied to flowering plants? Name five hardy perennials of your locality.

5. In starting a perennial border, how would you (1) prepare the soil, (2) arrange the different varieties?

6. Describe window-box gardening under the following headings: (1) Construction of the box, (2) Suitable plants, (3) Planting, (4) Care after planting.

7. Beautifying our home and school grounds makes for better social living. Briefly, but clearly, explain this statement.

There are many things that the pupils of a school can do to keep their school grounds appearing at their best. The boy at the left is cultivating the soil around the shrubs to keep the grass back and to prevent weeds from becoming established. The girl is trimming off loose ends that would give the shrubs a ragged appearance. The boy at the right knows that if the grass is cut frequently, it is best to leave the clippings on the lawn.

## MAKING THE BEST USE OF ARBOR DAY

Miss Peterson's pupils were near the end of a class meeting. Their president, Charlie Hunt, had just asked, "Is there any other business that anyone would like to bring before the meeting?"

"Yes, there is," Lillian Barker replied promptly. "I think we should make better use of Arbor Day than we have done in the past."

There was a stir of interest in the class. "What do you think we could do?" enquired Charlie.

"For one thing, we could plant some trees," Lillian explained. "There are several places on our school grounds where trees would look attractive."

Ronald Shaw had an idea, too. "Let's ask the School Board for some wire," he said, "and use it to repair the school fence."

It was decided to put on the blackboard a list of needed improvements, such as those given below. From the list, the pupils would select the most valuable suggestions for their attention.

1. Plant one or more trees. (This is one of the most important things to do on Arbor Day.) Plans must be made well in advance: be sure to prepare the soil; order trees from the nursery or select and mark trees in the woods; if necessary, arrange for a skilled gardener to be on hand.

2. Draw a plan of the school grounds and mark on it permanent improvements needed, so that work done each year will fit into a planned program.

3. Rake up the stones, pieces of glass, and other undesirable things that somehow or other have collected in the school yard.

4. Repair the fence — new fence posts might be needed, as well as wire.

5. Have a Parents' Day program. Show a film on *how to plant a tree.* Give short talks on such topics as the *value of trees, kinds of trees, evergreen trees, planting trees, conservation of trees and forests,* and other "tree" topics.

6. Cut the dead branches from the trees and shrubs on the school grounds. Cultivate the soil around the trees and shrubs.

7. Give the classroom an Arbor Day appearance by (1) putting up some tree pictures, (2) drawing sketches of trees and borders on the blackboard, (3) having bouquets from neighborhood trees and shrubs.

### SOMETHING TO DO

1. Use the list prepared by Miss Peterson's class as a *check list* for your school.

2. In some schools, the members of the graduating class follow the practice of planting a tree on Arbor Day. The tree is always known as *their* tree. Perhaps you would be interested in planting a tree to honor the first teacher in your school, a well-known pioneer in your district, or an outstanding citizen

in your community. Give the tree the name of the person in whose honor it was planted. If you are preparing to graduate, make plans to plant a tree in your school grounds this spring. Plan a program for the event.

### HOW TO PLANT A TREE

- Secure a tree from a commercial nursery or from a woods.
- Select a tree not more than 4 or 5 feet tall.
- Keep as much soil as possible on the roots.
- Plant the tree as soon as possible after it has been received from the nursery or dug up in the woods.
- Dig a wide, deep hole, and place some good topsoil on the bottom of it.
- Spread the roots out well. Plant the tree at the same depth as it was in its original location.
- Cover the roots with fine topsoil, and work the soil in well around them.
- When the roots are thoroughly covered, tramp the soil well, unless it is damp.
- Fill the hole with soil to within 3 or 4 inches of the top.
- Fill the depression around the tree with water several times.
- Prune off some of the branches to balance the reduced root systems.
- Support the tree with a stake to protect it from wind damage.
- Take good care of your tree. Keep it well watered.
- For further information about suitable kinds of trees and shrubs, and for directions regarding planting and care, review what you have learned about planting trees in Chapter 9, pages 311-315.

### TEST YOUR KNOWLEDGE AND UNDERSTANDING

1. Mention several activities in which your school might engage to celebrate Arbor Day.

2. Describe, under the following headings, the steps that should be followed in planting a tree: (1) Where to obtain the tree, (2) Size of tree, (3) Care of tree before planting, (4) How to plant, (5) Care of tree after planting.

A home of which any family could be proud. A glance through the open gate at the left shows that the back yard is also attractive. Examine this photo carefully. What in your opinion makes the view that we have of this home so attractive? (National Film Board photo)

### APPLYING WHAT YOU HAVE LEARNED

The best way to remember what you have learned about landscaping and gardening is to apply your knowledge to practical problems such as those listed in the Something To Do section that follows.

Select *two* or *three* of the following activities that best fit *your* school or home situation. If necessary, review the sections of the chapter that deal with the problems involved in the activities that you select.

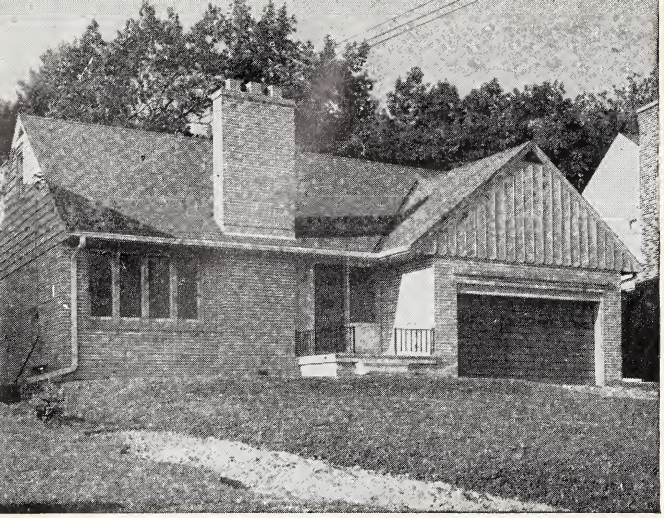
#### SOMETHING TO DO

1. Make a study of your home surroundings (front yard, back yard, etc.). Decide upon any improvements that you think would add to their attractiveness. Plan an outdoor living-room. Then carry out the following suggestion:

Draw a plan using a suitable scale, and show in a general way the location and arrangement of the main features. Among these, include some of the following: the house, the lawn, trees, shrubs, flower-beds, a vegetable garden, a bird bath, paths, a play-house, a garden seat, a hedge, a lily pool. Either print the names on your plan or devise some other system of indicating your arrangement.

2. Make a drawing of the front elevation (view) of an attractive home, showing the trees, shrubs, etc., in their proper relation to the house. This drawing should be made at some little distance from the home — across the street, for instance.

3. Suppose that you have a strip of garden 6 feet wide and 12 feet long between a walk and a garage or house wall. Make a plan drawn to scale (1 inch = 2 feet) showing how you would group the following plants in this bed: 4 delphiniums; 2 bleeding hearts; 2 peonies (pale pink); 18 snapdragons (copper colored, 2 feet high); 18 stocks (crimson, 1½ feet high); 24 sweet alyssums (white, 6 inches high).



Here is a fine new house. Soon a family will move in and begin to make it a home. A lawn has been planted, but much remains to be done outdoors. Prepare a list of things that must be done to give this house a more attractive appearance. (National Concrete Products Association photo)

When you have completed your arrangement, color the space occupied by each kind of flower to show the color display for the season. Hints: place stocks and snapdragons about 10 inches apart, and sweet alyssum 1 foot apart. See the chart on page 338 for suggestions about the perennials.

4. You wish to establish a wild-fruit corner in your back yard. Make a list of the trees and bushes that you would include. Where and when would you get your specimens? State all the ways in which you would expect to benefit from such a plantation.

5. Suppose there is a high, weathered, unattractive board fence at the back of your school yard. What could be done to improve the view in this direction? Suggest several solutions.

## WHAT HAVE YOU LEARNED?

### IMPORTANT SCIENCE IDEAS AND UNDERSTANDINGS

A

1. Beautiful grounds around your home and school will help to make your community a more attractive place to live in.

2. In arranging trees, shrubs, and flower-beds in your outdoor living-room, either a formal or an informal plan can be effective and beautiful.

3. There are many kinds of soil. Some kinds must be greatly improved before they are useful for a garden.

4. When planting flower-beds, it is important to consider the height of the full-grown plants, the time of flowering, and the color.

5. A green background, or foundation planting, of shrubs is often desirable to display to good advantage the bright colors of annual and perennial flower-beds.

6. Some annuals may be started outdoors in the garden, but many should be started early indoors or in a hotbed.

7. Transplanting is an important step in starting annuals early indoors.

8. Adequate warmth and light, and proper amounts of moisture and ventilation are essential in the operation of a hotbed.

9. A carefully chosen selection of perennials will provide a succession of colorful bloom from early spring until late fall.

10. Arbor Day is, above all, a day for *planting* trees.

(a) The foregoing sentences are all true statements of important science ideas and understandings. Read and discuss them carefully as a review of this chapter.

(b) The following sentences describe situations in which some of these ideas apply. To test your ability to apply ideas to actual situations, match the sentences in A with situations in B to which they apply.

B

1. One morning, Mr. Thompson found that a number of the young plants in his hotbed had fallen over as if rotted at the base. A neighbor told him that the cause was a disease known as *damping off*. Mr. Thompson had been watering the plants too heavily.

2. Mrs. Blair had very little space indoors for starting annuals early. She planned to sow some hardy, quick-growing varieties outdoors in the garden. However, she knew that certain other varieties, such as petunias and snapdragons, would not bloom until late summer unless she started them indoors.

3. The pupils in Westview School decided that this year they would make use of the first Friday in May to plant trees in suitable places on the school grounds.

4. In a garden that Elaine Scott visited during the summer, she noticed a very pleasing pattern. In a large circular flower-bed in the centre, the flowers were arranged so that their colors formed a beautiful design. Throughout the garden, a shrub in one location was planted to exactly balance a similar shrub in another spot.

5. On their way to and from school, Edith Brown and Marie Lucas often stopped to admire one home in particular. In the front

yard, there were two beautiful blue spruce trees. Several low-growing shrubs and colorful flower-beds partially framed the well-kept lawn. The girls noticed that they were not the only passers-by who stopped; the beautiful grounds were obviously being enjoyed by many people.

## IMPORTANT SCIENCE TERMS

### A

| | | |
|---|---|---|
| outdoor living-room | sandy soil | annual |
| formal style of planting | clay soil | hotbed |
| barnyard manure | loam | coldframe |
| commercial fertilizer | humus | transplanting |
| green manuring | nitrogen | hardening |
| foundation planting | compost | landscaping |
| bedding plants | perennial | Arbor Day |

To show that you understand and can use the science terms listed in A, match with the situations described in B those terms which apply.

### B

1. Jim Allison's family moved into a newly built house. The soil around the house had been levelled, but it was hard and grey in color. Jim's father bought several loads of manure, and Jim helped him to dig it well and deeply into the soil. Mr. Allison said that the manure would supply the soil's greatest need.

2. The back yard of the home of Mr. and Mrs. Olson was beautiful. To the north, it was enclosed by tall, thickly growing shrubs. To the east, a few trees and shrubs screened off the back lane. To the west was the house with attractive flower-beds and window-boxes. To the south, it was more open, but still sufficiently enclosed to ensure considerable privacy. At one place, a flagstone path crossed the lawn. In suitable locations were flower-beds, several garden seats, and a bird bath.

3. Mr. Kendal decided that his grounds would have a better appearance if he planted a few shrubs close to certain parts of his house. He noticed, however, that in a neighbor's yard the shrubs were too large and were crowding everything else out. As a result, Mr. Kendal planted only a few low-growing varieties.

4. One day, Mr. Shaw noticed that the young plants in his hotbed were becoming badly crowded. Taking one box after

another, he moved each tiny plant to another box. This time, he spaced them about 2 inches apart.

5. Mr. Grant saved all plant tops, leaves, etc., from his garden. He put them in a pile mixed with soil. From time to time, he moistened the pile well to hasten the decay of the plant materials. In this way, he always had a supply of plant material to dig into his soil.

**SCIENTIFIC METHOD AND ATTITUDES**

1. Mr. Barker was starting a new lawn. He carefully prepared the soil and planted the seed.

Mr. Barker had not known very much about planting a lawn, so he had done some reading and made enquiries among friends who had good lawns. One of the things that he had learned was that when a new lawn is being started, the soil must be kept moist at all times until the new grass plants are well rooted and growing vigorously.

However, it seemed a lot of trouble to keep watering and watering. There were times when the soil became quite dry before Mr. Barker got around to watering it. As the lawn developed, there were some places, which apparently had not dried out too much, where the grass grew thick and green. But in other places the grass was extremely thin, and there were many bare spots.

Mr. Barker was very disappointed. He decided that the seed he had used could not have been good. He made up his mind to try again the following year, using different seed.

(*a*) What evidence is there in the foregoing account that the seed was not responsible for Mr. Barker's lawn failure?

(*b*) What was the cause of his poor lawn?

(*c*) In what ways did Mr. Barker follow the scientific method?

(*d*) In what ways did he not follow good scientific procedure?

2. Among the perennials that provide a wealth of color in the flower garden are the delphiniums. Mr. Brown decided that he would like to have some in his garden. He consulted a nursery catalogue and a friend who was a very successful delphinium-grower. Both the catalogue and his friend gave him a great deal of information about the right kind to buy.

When Mr. Brown went to a seed store to buy delphinium roots, the store did not have in stock the kind that had been recommended. The clerk said that it did not make much difference what

kind of root was used; besides, the kind the store had in stock was cheaper than the kind for which Mr. Brown had asked.

Later, when Mr. Brown's delphiniums came into flower, he was very disappointed. When he compared his blooms with those of his friend, he found that his flowers were smaller and that the color combinations were not nearly so attractive.

(*a*) Mr. Brown followed good scientific procedure in reading and in going to his friend for information. Why was this a good thing for him to do?

(*b*) Why did Mr. Brown not follow his friend's advice?

(*c*) Do you think that Mr. Brown showed a good scientific attitude in connection with his delphinium activities? Why?

3. A gardener wanted to know if the use of vitamin B would improve his geraniums. He selected two potted geraniums, A and B, which were as nearly alike as possible in size, age, appearance, and type of soil in which they were growing. He kept both plants under the same conditions of temperature, light, etc. He gave both plants exactly the same amount of water from day to day. Once a week for six weeks he watered plant A with vitamin B solution, while plant B was given ordinary water. After six weeks, he observed that plant A was larger and had more leaves and larger blooms than plant B. The gardener repeated the experiment with other plants and got the same results.

(*a*) By answering the following questions you will see how the gardener used the scientific method to find the solution to his problem. (1) What was the *problem* of this experiment? (2) What *apparatus and material* did the gardener use? (3) What did he do with this material? *(method).* (4) What *observations* did he make? (5) What would be his *conclusion?* (6) What use or *application* could the gardener make of his results?

(*b*) List the conditions that were the same for both plants. What condition was different?

(*c*) Which plant served as a "control"? Would the results have been as convincing if no control had been used? Why?

(*d*) Was it necessary for the gardener to repeat the experiment before coming to a conclusion? Explain. Instead of repeating the experiment, the gardener might have used, say, six geranium plants — three for the control group (no vitamin B) and three for the experimental group (given vitamin B). Would this have been a better experiment? Give reasons for your answer.

Ontario Department of Lands and Forests

*Insects, if given a chance, would make a meal of the finest forest giant.*

*—Selected*

# CHAPTER 12

CHAPTER 12

# CONTROLLING PLANT ENEMIES

**Our fight against plant enemies has been described as one of the greatest wars of all times. Many diseases, insects, and weeds seriously damage the plants that supply us with food, clothing, and building materials. What are some of the enemies that feed upon our crops or rob them of their food supply? How can you protect your crops or your flower garden from these enemies? Nobody likes weeds. Why? What makes a plant a weed? What can you do to help to get rid of weeds?**

Gary Morin and Roy Kendal had undertaken an excursion of discovery. They had just learned at school that every living thing has enemies and that among plants and animals there is a constant struggle for food. Miss Peterson had suggested that they might find evidence of this struggle by making first-hand observations in their own garden.

"I've never seen any enemies attacking plants in our garden," said Roy.

"Neither have I," said Gary. "But let's see what we can find, anyway."

As they crossed the lawn, Roy stepped on a big dandelion plant without noticing it.

"Wait," said Gary, "let's examine this plant."

"It's just a harmless dandelion," remarked Roy.

But when they lifted the big leaves of the dandelion, they found that the grass underneath them had died. When further investigation showed that this was usually the case, the boys concluded that dandelions smother the grass.

"So the dandelion is an enemy of the grass, after all," admitted Roy.

In the garden, Gary and Roy found many other plant enemies. Pigweeds and mustards were taking moisture and food from the soil around the carrots and parsnips and were steal-

Insect pests, weeds, and plant diseases must be kept in check in order to achieve a beautiful garden like the one pictured here. Constant vigilance must be exercised in all parts of the garden.

ing their sunshine. A patch of French-weed was coming up so thickly that, if it were left undisturbed, it would completely crowd out the slower-growing asters.

But weeds were not the only enemies the boys found. In the cabbage patch they observed many leaves full of holes. On close examination they discovered many small green caterpillars feeding on the leaves.

"Miss Peterson was right, wasn't she?" said Gary.

"Oh, I don't know," Roy replied. "These are all little plants. Those big maples and the Virginia creeper that covers the porch are too big to have dangerous enemies."

"That's where you're wrong," said Gary. "See how many of the leaves of this maple tree have turned brown."

When they observed the trees closely, the boys found that whole colonies of plant lice or aphids were sucking the juice from the leaves. In other parts of the garden they found other plants suffering from a blight or plant disease.

On their tour of the garden, the boys made many interesting discoveries, which opened a new field of thought to them. When they seek further, they will find that each plant enemy itself has enemies. The green plant lice that feed on the maple, for example, are devoured by the lady-bird beetle.

The next day in class, other pupils reported other plant enemies they had observed — plant diseases, harmful insects, and weeds.

The plants we like to grow — domestic plants — are often less hardy

than their enemies and could not thrive without our aid. So we check weeds, poison harmful insects, and spray blights to prevent them from destroying what we want to grow. You will learn in this chapter about the most dangerous crop enemies and how they can be controlled.

## PLANT DISEASES

Plant diseases damage our crops to the extent of many millions of dollars every year. In every part of Canada, plant "doctors," or plant pathologists as they are called, are studying diseases of plants to learn more effective methods of controlling them. In other countries, also, a great deal of money and time is being spent in an effort to prevent this waste. In a campaign of this kind, we can all help if we are able to recognize the symptoms of the more common plant diseases and know how to prevent or control them.

Most plant diseases are contagious and are spread from plant to plant by *spores*, just as diseases that attack us are carried from person to person by germs. The spores, which are extremely tiny, may be blown from one plant to another by the wind; they may be spread through the soil; or they may attack the seeds and infect the young plants that grow from the seeds.

This illustration shows how a plant disease may damage a crop. Left: A badly rusted crop of a susceptible variety of wheat. Right: A rust-free crop of a resistant variety. Which crop will produce the higher yield? (Regina Experimental Station photo)

Plant diseases are caused by very, very small plants that belong to the group of plants called *fungi* (fun'jī; singular — *fungus*). Fungi contain no chlorophyll or leaf green and therefore are unable to make their own food, as green plants do. *Mold*, like that which you have probably seen growing on moist bread, orange or lemon skins, etc., is a common fungus. You know that when you have a cold, measles, or mumps, germs are growing in your body. When wheat is infected with *rust*, we know that a fungus has begun to grow in the wheat stems; and when a disease called *wilt* appears in flax, we know that bacteria have begun to grow in the flax plants.

Sometimes water and milk are not safe to drink until they have been treated to kill disease germs in them. Neither is some seed safe to plant until it has been given treatment to destroy disease spores it may be carrying. The most usual method of treating seed is to apply a chemical that kills the spores without harming

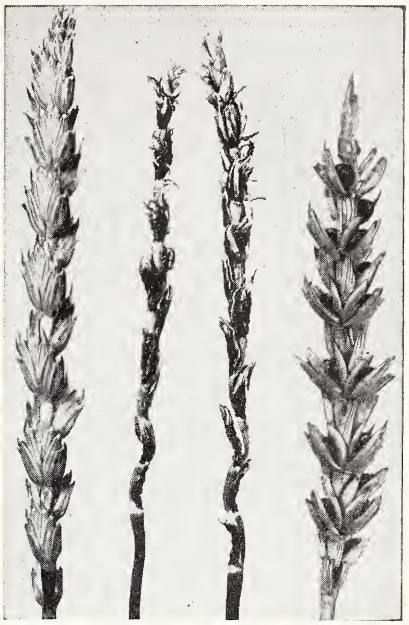
the seed. Many farmers make a practice of treating their seed grain every spring before sowing it.

### The smuts of grains

Several kinds of smut attack wheat, oats, barley, and corn, causing losses amounting to millions of dollars yearly.

*Covered smut,* or as it is also called, *bunt* or *stinking smut,* affects the seeds of wheat. During the summer, while the crop is growing, the smut fungus develops within the wheat plants. Later, the kernels, instead of filling out as they should, develop into spore packages called *bunt balls,* which are filled with several million tiny spores. At threshing time, the threshing machine breaks the bunt balls, and the spores are scattered. They become lodged in the woolly ends and the creases of healthy kernels. There they remain inactive during the winter. The following spring, when the seed is sown, the spores start to grow and infect the new wheat plants.

Covered smut of wheat may be controlled by: (1) *Cleaning seed* thoroughly to remove bunt balls and light seeds which might be diseased. (2) *Treating the seed* to kill the spores on the wheat kernels. For this purpose a chemical preparation containing mercury (trade names — ceresan, leytosan, etc.) is applied to the seed either as a dust or in liquid form. This chemical is poisonous and must be handled with the greatest care. (3) *Sowing varieties that are resistant to smut.*



The smuts of wheat. Left: A healthy head. Centre two: Heads infected with loose smut. Right: A head infected with bunt or covered smut; notice the bunt balls. (Dominion Department of Agriculture photo)

Oats and barley are also affected by this type of smut. Before being sown, all seed wheat, oats, and barley should be treated.

Another kind of smut *(loose smut)* lives inside the seed and is hard to control, requiring a difficult hot water or other special treatment.

Other diseases, such as *rust, take-all,* etc., also affect grains, but these cannot be controlled by seed treatment, because they do not infect the

Corn is also affected by smut, as you can tell by examining this photograph. Notice the tassel and the lower part of the plant. Compare with a healthy corn plant. (Ontario Agricultural College photo)

seed. Plant scientists are at work in laboratories in Ottawa, Guelph, Winnipeg, Saskatoon, Lethbridge, and elsewhere, searching for new disease-resistant grains and other crops.

### Cereal rusts

Another group of plant diseases, causing damage to the extent of many millions of dollars annually, includes the several kinds of rust which attack the stems and leaves of wheat, oats, and barley.

Stem Rust of Wheat. — This fungus attacks principally the stems of the wheat. The disease is spread from wheat plant to wheat plant by spores carried by the wind. When a spore falls on the stem of a wheat plant, the rust fungus begins to grow *in* the stem. It feeds upon the sap. As a result, the heads of the wheat are starved, and small shrunken kernels are produced.

Since rust is not spread by seeds, seed treatment is useless. Preventative measures are the only means of control.

1. If the wheat crop can be encouraged to ripen before the rust season, it will escape serious damage. This may be accomplished by using early-ripening varieties, sowing the seed early, and using seed of strong germinating power.

2. The most effective way of controlling rust lies in sowing *rust-resistant varieties.* For many years, Thatcher, Apex, Regent, and other varieties were immune to the attacks of the rust fungus. However, there are many races of stem rust, and in the early 1950's, a rust called 15B seriously damaged the wheat crop. All varieties of wheat were attacked except Selkirk, a newly introduced variety. But even Selkirk did not prove to be immune.

Joan Wilson reported to the class that she had read in a newspaper that in 1954 a new rust, 15B3, appeared and attacked even the new Selkirk. It is evident that the battle against the rust disease has not yet been won and must be continued in the years ahead.

Stem rust of wheat. Left: Stems of a susceptible variety, showing numerous openings filled with spores. Right: Stems of a rust-resistant variety. (Dominion Department of Agriculture photo)

**STOP — READ — THINK**

As you know, there are several ways of studying science:

1. *trying things out for yourself* — experimenting
2. *seeing things for yourself* — outdoors and indoors
3. *reading* — in books, magazines, newspapers
4. *asking persons who know* — a good source of information

If you are *not* making use, from time to time, of all these ways of studying science — if, for example, you are only reading about science — you are missing many pleasant, profitable experiences and wonderful opportunities of adding to your store of knowledge.

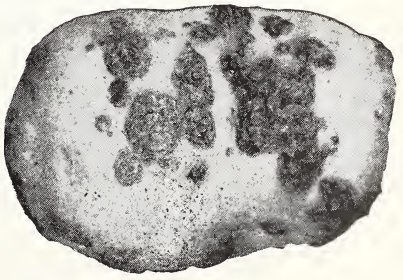
### Common scab of potatoes

Common scab is a very prevalent disease of potatoes. You have seen that it causes the skins of potatoes to become rough and very unsightly. Scab is caused by a fungus that winters in the tubers or in the soil. It does not reduce the yield of the crop to any great extent, but it results in heavy losses because scabby potatoes are not very saleable. This disease is often spread by planting scabby potatoes.

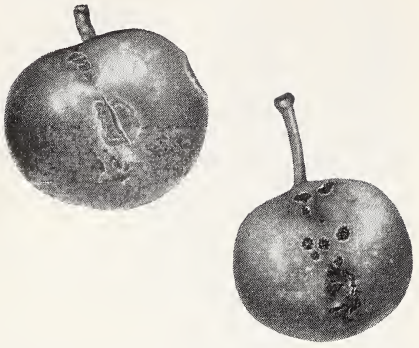
Common scab may be controlled by soaking seed potatoes in a solution of corrosive sublimate.

### Other plant diseases

Most of our crops — grains, fruits, vegetables, and even some of our ornamental plants — may become infected with diseases. Many different methods are used to prevent and control the various diseases. In some cases, the seed is treated, as described on page 413. In others, the plants are sprayed with chemicals to kill the spores on their leaves. In still others, diseased plants are rogued, or pulled up, and destroyed. Where the disease lives in the soil, crop rotations are frequently planned, so that the same



Common scab on a potato tuber. Watch for scab in your own potato patch. (Dominion Department of Agriculture photo)



Apples may be infected by a number of diseases. Here are two apples infected with apple scab. (Ontario Agricultural College photo)

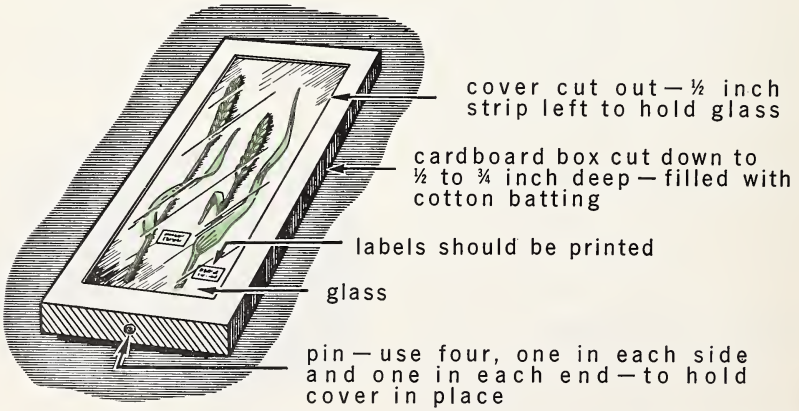
kind of crop may not be grown too often in the same soil.

Trees, like other plants, are subject to certain diseases. Some tree diseases are described in Chapter 9. Which ones cause the most damage? What are scientists doing to develop methods of control?

#### SOMETHING TO DO

1. Make a collection of plant disease specimens. Include, if you can, rust of wheat and other grains, loose and covered smut of various grains, ergot on rye, other diseases of grains, such as root rot, common scab of potatoes (dry and press a thin slice of scabby potato peeling), etc. Your collection may be mounted and preserved in the manner illustrated in the diagram at the bottom of the page.

2. Watch the newspapers and farm magazines for accounts of the work being done with plant diseases, such as rust and other diseases of grains. Although much has already been accomplished, further progress will no doubt be made in the near future in developing disease-resistant crops by careful selection and cross-breeding.


cover cut out — ½ inch strip left to hold glass
cardboard box cut down to ½ to ¾ inch deep — filled with cotton batting
labels should be printed
glass
pin — use four, one in each side and one in each end — to hold cover in place

The above drawing illustrates a good method of mounting plants and insects. Use waste pieces of glass and boxes. Check your information carefully before printing your labels.

**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

1. What kinds of enemies attack plants? What enemies did Gary and Roy find in their garden?
2. What are fungi? How are fungi different from other plants?
3. How are contagious diseases spread among people?
4. What causes diseases of plants? How are these diseases spread?
5. How may seed wheat be treated to prevent the crop from being infected by covered smut?
6. What treatment is used to prevent common scab in potatoes?
7. How is the cereal disease, *rust*, spread from plant to plant? How is rust controlled? Tell what you know about Selkirk wheat. What information have you about 15B3 rust?
8. What newspaper or magazine articles have you read recently that told about the fight against plant diseases? Tell a story of the work that scientists are doing to help farmers and gardeners control harmful plant diseases.

## INSECT PESTS

Numerous insect pests are at work everywhere. To control them is a gigantic undertaking. Many insects are our friends, but an enormous number are very injurious. In Canada, the average yearly loss from insects is over $350,000,000.00. It has been estimated that, in this country alone, insects annually destroy the work of 100,000 able-bodied men. Like plant diseases, they seriously damage plants that provide us with materials for food, clothing, and shelter. Man must wage active and constant war against harmful insects.

**SOMETHING TO DO**

Even harmful insects are interesting!

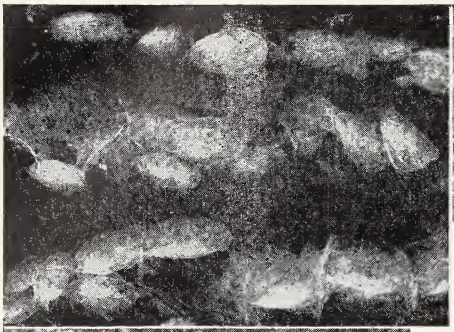
1. Injurious insects may be seen at work on many kinds of plants. *Arrange for a field trip* so that you will be able to learn more about them.

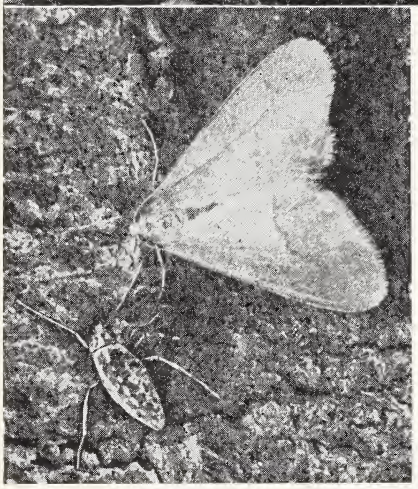
*Look for*: rose beetles; leaf-cutter bees (watch for circular pieces cut out of rose leaves); aphids or plant lice on Manitoba maple, elm, delphinium, roses; cabbage butterflies and larvae; potato beetles; grasshoppers; cutworms; and many others.

2. Make a careful study of one insect that damages our crops. (1) Look for it in gardens or fields. (2) Draw sketches to illustrate its habits and life. (3) Watch magazines and newspapers for information about it. (4) Collect specimens of the various stages of its life-history. (5) Learn how to control it.

### Cutworms cut crop yields

Charlie Hunt and Ben Olson had a splendid garden. They had really





The white-marked tussock moth. The larva (above, right) is a caterpillar with four white tussocks, or tufts, on its black-and-yellow striped body. The greyish, silky cocoons (above, left) are formed on tree trunks. The female adult, shown beside the male (below, left), is wingless. About 400 eggs are laid on the old cocoon and covered with froth. The adult male is an ashy-grey moth with a wingspread of 1¼ inches. The tussock passes the winter in the egg stage. The caterpillar causes damage to shade and fruit trees. Control consists of (1) destroying cocoons, (2) banding trees with sticky materials to prevent the movement of caterpillars and females to new trees, and (3) spraying the leaves of infested trees with poison. (Hugh M. Halliday photos)

worked hard to plan it well, prepare the soil thoroughly, and otherwise do all they could to make it a success. One evening they spent several hours transplanting cabbage plants from boxes to the garden. When they were finished, they were very proud of their young cabbages lifting up their leaves in straight, well-spaced rows.

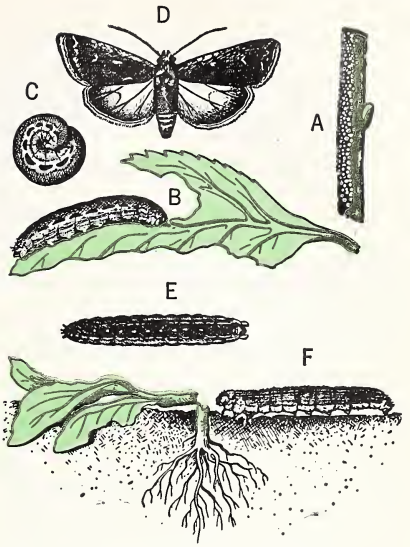
A few mornings later, Charlie and Ben were keenly disappointed to find that the tops of many of their cabbage plants had been cut off. Digging into the soil around the damaged plants, they found several grey-colored caterpillars tightly curled up. What should they do? Next door in Mr. Osborne's garden no damage had been done. So the boys went to him for assistance. He told them their plants had been ruined by *cutworms*, and explained to them how to control these very harmful insects by using paper cylinders and poison bait.

Charlie and Ben took several of their damaged plants to school and related what they had learned from Mr. Osborne. The class wanted to know more about cutworms.

Cutworms are a constant menace in spring to the production of practically all crops of field and garden.

They attack juicy plants wherever they can find them. Their control is one of the greatest problems of the gardener and farmer. Cutworms are a kind of caterpillar. The adults are night-flying moths, commonly called *millers.*

There are many kinds of cutworms. One of the most widely distributed and harmful is the *red-backed cutworm.* Another is the *variegated cutworm.* Both of these cutworms are very destructive in gardens. A third kind, the *pale western cutworm,* is, as its name implies, injurious in the grain fields of Western Canada.




A to E, life story of the variegated cutworm: A, eggs; B, C, and E, caterpillar or cutworm; D, adult moth. F, red-backed cutworm and damaged plant. (Redrawn with permission of the United States and Dominion Departments of Agriculture)

**The red-backed and variegated cutworms**

By studying about the red-backed or variegated cutworms, you can learn much about the others.

The adults of these cutworms are medium-sized, greyish-brown moths with a few white marks and dark-colored areas on their front wings. They are common in late July and August.

The eggs, which are very small, are laid in fine, loose, dry soil during the late summer. They hatch during the first lengthy warm spell in the following spring.

From the eggs, tiny larvae or caterpillars hatch. These are the cutworms. They are dark grey in color, with two broad bands of red along their backs. When full-grown, a cutworm is about as thick as an ordinary lead pencil and about one and a half inches long. When it is disturbed, it curls up into a ring. Cutworms remain below the ground during the day, but come above the surface of the ground at night to feed. The harm they cause is very great. Sometimes they merely cut the plants off at or near the surface of the soil. At other times they eat the leaves as well. Usually they can be found by digging into the loose soil near the plants they have damaged during the night. Cutworms are full-grown and cease feeding about the end of June.

They then build a small, oval, earthen cell one or two inches below the surface of the soil. In this cell they pass the pupa stage, remaining

DANGER – KEEP UP-TO-DATE

Recently a number of deaths have been caused by careless and improper use of insecticides. It is very important, therefore, that you handle all insecticides with care. Be sure to read the instructions to be found on the labels of the insecticide containers which include:

—safety precautions to be observed.

—specific instructions as to when and how to use the insecticide.

New insecticides are made available on the market every year. Some of these replace those formerly recommended. Therefore, to keep up-to-date, you should consult the most recent publications of the Department of Agriculture in your province.

inactive while they change from cutworms to moths. The pupae are dark reddish-brown in color. They may often be found in garden soil. After about three or four weeks, the adult moth emerges.

The change from caterpillar to adult (moth, butterfly, beetle) that takes place in the life of many insects, is known as a *complete metamorphosis.* The word *metamorphosis* means "change in form." The cutworm is a good example of an insect that undergoes a complete metamorphosis involving four stages: egg, cutworm, pupa, and adult.

Scientists have used their knowledge of the life-history of the cutworm to develop methods of control such as the following:

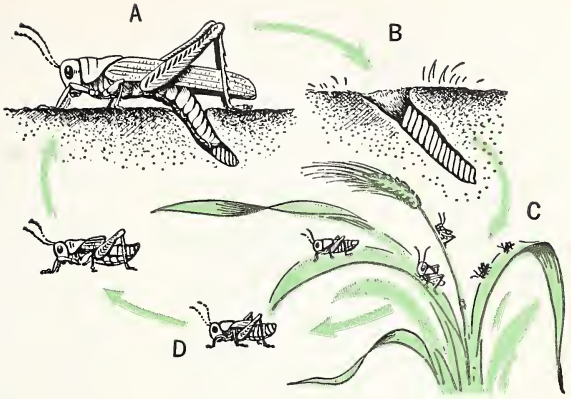
1. They know that cutworms (1) have biting mouthparts and eat the leaves of plants, and (2) come to the surface of the soil at night to feed. As a result, they have made available to the farmer and gardener certain *sprays* and *dusts* that destroy the insects. Most poisons can be mixed in water and applied as sprays or used in dust form on infested crops in larger fields. Some may also be sprayed on the soil before the crop is planted.

Before cutworms start cutting through the stems of cereal grains, they cut shot holes in the leaves. Farmers and gardeners need to watch for this and take control measures before it is too late.

2. Scientists have learned that the cutworm moths lay their eggs in the soil among weeds rather than in bare soil that is loose or crusted. Therefore, they recommend that fields in which there are likely to be cutworms, should be *cultivated early* in the summer *to ensure the destruction of weeds.* Then *the soil should be left undisturbed* so that a *crust* will form on it.

3. In gardens, *a cylinder of tin or heavy brown paper* placed around individual plants as they are set out will protect the plants.

4. *Insect-eating birds* are natural enemies of the cutworms, and should be protected.




The life-history of the grasshopper. A: The female grasshoppers lay their eggs in grassy knolls in the late summer. B: An egg pocket in the soil containing white, oval-shaped eggs. C: Very young grasshoppers, called *nymphs*, not long emerged from the eggs in which they started life. They have no wings. D: A nymph several weeks old; its wings are beginning to develop.

### The pale western cutworm

The pale western cutworm is pale slate-grey with a yellowish head, on the front of which are two black marks. Since these cutworms feed about one inch below the surface, poison baits are not effective. However, sprays such as endrin are very useful. As the moths lay their eggs in loose, dusty soil, leaving the soil uncultivated and crusted from August 1 to September 15 will prevent egg-laying activities. Young cutworms may be starved by destroying all green plant growth about two weeks before the crop is to be seeded.

### Grasshoppers

The nymphs and adults are much alike. Grasshoppers are a good example of insects that undergo an *incomplete metamorphosis* as they grow up. There are three stages in their development: *egg, nymph,* and *adult.*

Grasshoppers are controlled chiefly by: (1) spraying with insecticides the crops being attacked. At time of writing dinethoate, malathion, and Sevin are recommended for use with field crops. The insecticide Sevin is in dust form and must be mixed with water. It can be used in field or garden. When used to spray garden vegetables a waiting period of three or four days should be allowed before any vegetables that have been sprayed are used for food. (2) Cultivating, before June 1, a guard strip two or three rods wide around fields to be summerfallowed (no crop, soil cultivated during summer). Cultivate the remaining fields in sections, leaving strips of weeds between the cultivated strips. The grasshoppers gather in the strips, which should be sprayed.

#### SOMETHING TO DO

1. Look for cutworms in the spring. Bring specimens of the various kinds to school to show your classmates.

2. Look for cutworm pupa cases in the garden in the early summer. Place some in a box in a moderately warm place, and watch for the moths to

emerge. Keep the cases at home in order to observe the moths when they appear.

3. Watch grasshoppers to see how they are fitted for their way of living. Notice their legs, armor, wings for protection and wings for flying, biting mouthparts, etc. Observe how their coloring protects them when they are at rest.

4. Try to see a grasshopper laying eggs. In grassy fields and roadsides or in bare soil in stubble fields or pastures, look for grasshopper egg pods.

5. Work out, from your own observations, the life story of the cabbage butterfly. How does it spend the winter? How many broods are there each year?

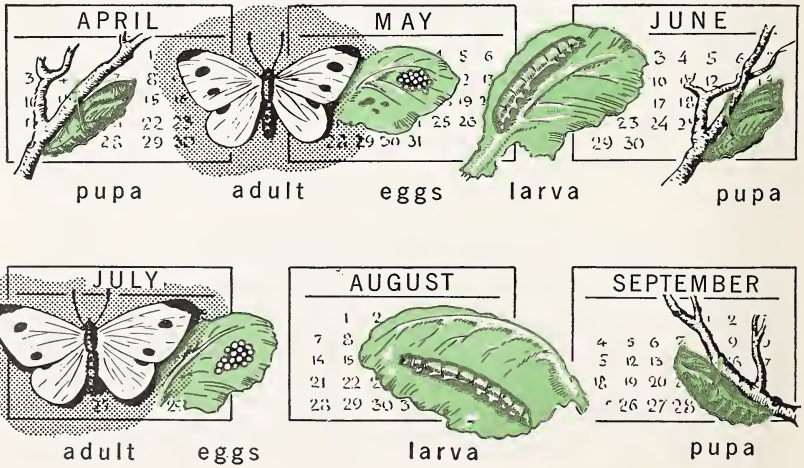
The life-history of the destructive cabbage butterfly. The adults are medium sized, yellowish white butterflies with black markings. The calendar pages tell the time of year in which the various stages occur. It winters in the pupa stage. The eggs and larvae are found on the leaves of cabbages. The larvae are destroyed by poison sprays or dusts — early in the season, derris, pyrethrum, or DDT — later use only vegetable sprays that are harmless to man, such as derris or pyrethrum.

### AN UNDERSTANDING OF IDEAS IS IMPORTANT

Many details, such as the names of insecticides, are included in our story of insect control not necessarily to be memorized, but rather to give you an idea of the vastness and the difficulty of the problem.

It is also important to learn how to recognize the insects studied, and to understand how a knowledge of their metamorphosis helps in controlling them.

As you read and think about this information, you will have a much better knowledge and understanding of how the scientist works with the farmer, the gardener, and others to provide us with food, clothing, and materials for our homes.



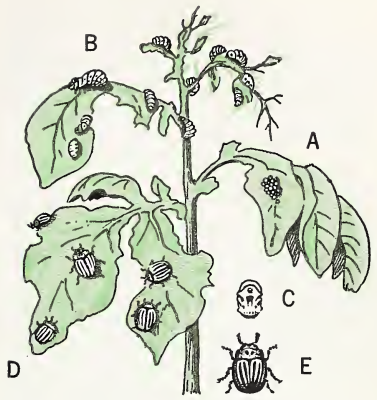
**The Colorado potato beetle or "potato bug"**

Lou Baker and Howard Kovack were neighbors. They had learned that there is an interesting story almost everywhere you look outdoors. They were always on the watch for the unusual.

The boys' fathers each had a part of his garden planted in potatoes. One day Howard noticed that the leaves on his father's potato plants were beginning to disappear. Over in the garden at Lou's home, the potatoes were flourishing. When the boys examined the damaged plants, they found many small reddish insects. There were no insects on the plants belonging to Lou's father. Lou knew that his father sprayed his potatoes against insects. The boys wondered what the insects were called and where they had come from. They decided to find out.

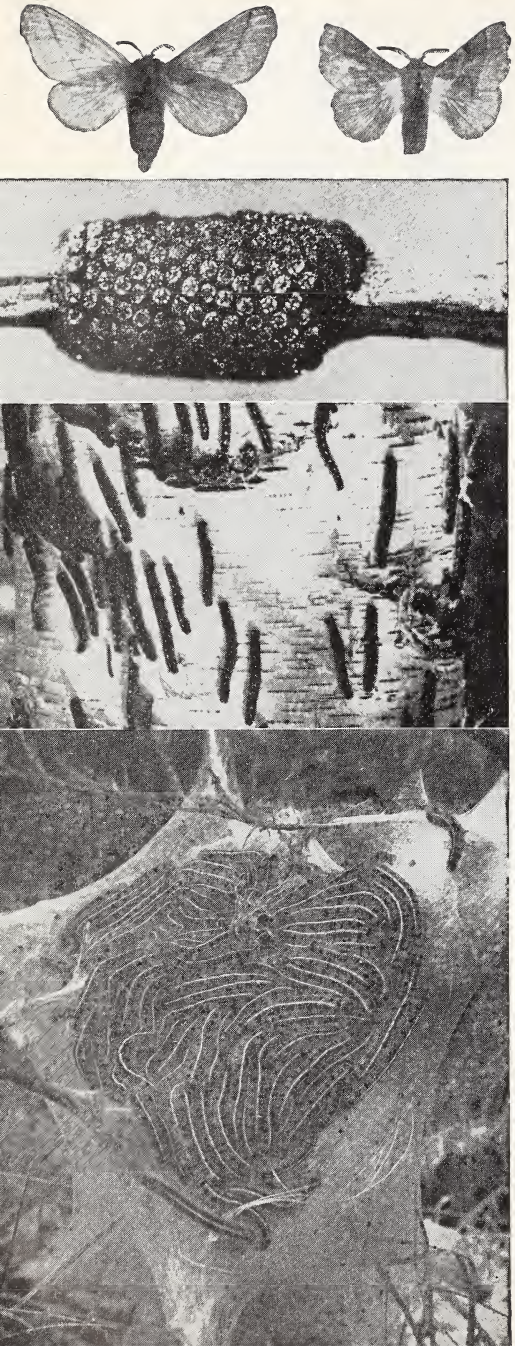
When Mr. Baker returned home, the boys asked him many questions. He told them that the insects were *Colorado potato beetles,* often wrongly called "potato bugs."

Both the adult and the larva of the Colorado potato beetle feed ravenously upon the leaves of potato plants. They may completely destroy the leaves of an entire patch unless they are checked as soon as they are discovered. The adults, which are not bugs but beetles, pass the winter in the ground. In the early spring they emerge, and the females lay numerous orange-colored eggs on the leaves of early young potato plants. The eggs hatch in a week or ten days. The larvae are full-grown in two weeks, after which they bury themselves in the ground to pass the pupa stage. In about two weeks more, the adult beetles emerge from the pupa cases. They at once lay more eggs for a second family, which by fall will have reached the adult stage.




Part of a potato plant badly infested with one of its worst enemies, the Colorado potato beetle. The four stages of its life: A, eggs on the underside of a leaf; B, larvae devouring leaves; C, pupa; D and E, adult beetles. E is natural size.

As they have done in the case of so many other injurious insects, scientists have developed effective methods of controlling the Colorado potato beetle. Poison sprays that have been widely used such as derris, DDT, or aldrin when sprayed on the leaves of potato plants, destroy both larvae and adults. It is often necessary, however, to spray the plants repeatedly in order to obtain the desired results.



The tent caterpillar. From top to bottom: Adult moths of forest tent caterpillar; eggs (enlarged), usually covered with a froth that has been mostly scraped off in this photograph; forest tent caterpillars on a white birch tree; orchard tent caterpillars in tent. (Department of Agriculture, Ontario Department of Lands and Forests, and Hugh M. Halliday photos)

## Tent caterpillars damage orchard and forest

It was early June. The trees were green and beautiful in their early summer foliage. Then, one day, they were almost as bare as in winter. Hardly a leaf remained! What had happened?

It had all begun the previous fall, when small rusty-brown *moths* (wingspread about 1¼ inches) laid bands of *eggs* on the twigs of the trees. In the spring, small brownish *caterpillars* emerged from the eggs. When full-grown, the caterpillars were about 1½ inches long. They fed upon the leaves of the trees.

There are several kinds of these caterpillars. When at rest, some cluster in groups on the trunk and larger branches. Others form large *webs* or *tents*, from which habit they receive the name of *tent caterpillar*. Some tent caterpillars are found on forest trees, such as poplar, red oak, sugar maple, birch, ash, and elm. Others infest orchard trees, such as the apple. They often cause widespread and serious damage to valuable trees.

When full-grown, the caterpillars spin yellow cocoons in cracks and rolled-up leaves and on fences and

buildings. In the cocoons, they change, in from ten to fourteen days, from caterpillar to moth. Then the moths lay more eggs which remain over winter.

Tent caterpillars have many natural enemies — dragonflies, ants, and certain small flies and wasps that feed upon the adult moths and the larvae. Nevertheless, control measures are necessary to prevent them from stripping the leaves from large areas of trees. Airplanes are used to scatter DDT in the forests. In orchards, the trees are sprayed with DDT, or derris or pyrethrum. Small colonies may be burned out, using an oil-soaked rag on a pole.

Other insects that damage trees are described on pages 332 and 333.

Using modern methods to apply a poison spray to protect these large, beautiful trees from enemy insects. The battle against plant enemies must be continued unceasingly in garden, field, and forest. (Department of Agriculture photo)

### Sap-sucking insects

Many insects, like the cutworm, the grasshopper, and the potato beetle are equipped, as you have learned, with biting mouthparts. They bite off pieces of plants. Others have mouthparts fitted for piercing and sucking. Insects in the latter class bore into plants and suck the sap. *Aphids,* or *plant lice,* are common examples of injurious sucking insects.

#### SOMETHING TO DO

Find some aphids. They are common on house plants, currant bushes, Manitoba maple trees, and other plants. They are quite small and are usually green in color. Most of the leaves on which they are feeding will be curled up. Bring a branch or plants to show your classmates. Observe them for a short time, then be sure to destroy them. Use a magnifying glass for your observations. You will probably find some of these insects with their tube-like mouthparts plunged deep into the plant, apparently sucking sap greedily. You may see some that have wings; others will be wingless.

Aphids produce a sweetish liquid or honeydew. They are often so numerous on Manitoba maple trees that the liquid falls from the leaves in a sticky shower. Sometimes ants take aphids into ant-hills to supply them with honeydew in winter. Aphids may be useful to ants, but man regards them as wholly harmful, since they destroy many useful plants.

Plant lice on the leaves and stems of a rose. (After Hudson, Entomological Branch, Department of Agriculture)

Since aphids do not eat the plant, placing poison on the leaves will not destroy them. They must be controlled by sprays that clog up their breathing pores or that contain poisons which affect their bodies.

A useful soap solution for killing aphids may be prepared by adding one pound of soap to from four to six gallons of soft water. Certain sprays, such as malathion or other chemical spray which may be purchased from florists, are effective in destroying aphids. DDT is also widely used. It is important to spray *before* the leaves are curled.

#### SOMETHING TO DO

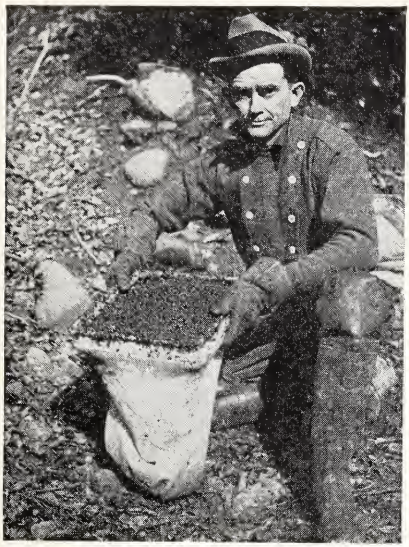
1. Make a collection of insect pests that destroy our crops. For detailed instructions about how to collect and preserve insects, write to the Director of Publicity, Department of Agriculture, Ottawa, for a copy of *Directions for Collecting and Preserving Insects,* Circular No. 520.

Ladybird beetle. Left: larva stage; Right: an adult. The life-size ladybird beetle is one-quarter inch or less in size. Why are ladybird beetles our friends? (United States Department of Agriculture photos)

2. Organize committees to make a survey of the damage that harmful insects are causing in gardens or grain fields in your community. Find what control methods are being used to keep the insects in check.

### Fighting insects with insects

Certain insects are being used more and more in the fight against harmful insects. Men are searching the world over for insects that prey upon other insects which damage crops. Within the last few years, insects have been shipped from Great Britain to help to control sawflies on the Canadian prairies. In newspapers and magazines, you may see accounts of other similar imports.

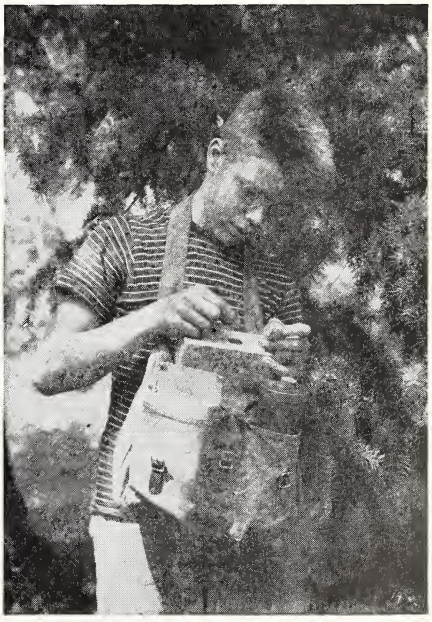


Ladybird beetles are grown in Australia for shipment to various parts of the world to help control harmful insects.

The small, red-colored, black-spotted insects that we call "lady-bugs" are not bugs at all, but beetles. Their correct name is *ladybird beetle.* Both the larvae and the adult ladybird beetles feed on aphids which infest house-plants and many plants out-of-doors, and thus are very helpful in keeping these harmful insects in check. In California, ladybird beetles are collected and used for this purpose in melon patches and fruit orchards.

Entomology is the science of the study of insects. In Belleville, Ontario, the Research Institute, Canada Department of Agriculture, was established for the purpose of studying parasites for insect control (a *parasitic insect* is one that feeds upon other insects). When an insect is found that will be useful in controlling an injurious pest, it is multiplied and distributed for this purpose. The Laboratory has been in operation over 30 years. It has studied 25 insect pests and has distributed over 950,000,000 parasite insects. There is also an Entomology Research Section at the Canada Department of Agriculture Research Station in Lethbridge, Alberta.

As you know, we must wage a continuous war against insects that damage our forests. This boy is collecting parasites that affect the *spruce budworm,* an insect that causes widespread and serious damage. The parasites will be sent to the Belleville Parasitic Laboratory for study and distribution. (Belleville Parasitic Laboratory photo)



**SCIENTIFIC ATTITUDE**

It may be a new idea to you that there are beneficial or useful insects — insects which instead of being destroyed should be protected.

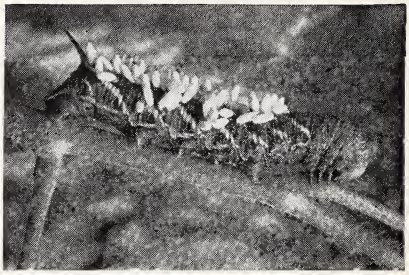
Remember, one important scientific attitude is being open-minded, that is, willing to change your opinion when you have new and accurate information.

By looking in other reliable books, check the information, presented to you in this text, about ladybird beetles, praying mantes, and other beneficial insects.

The praying mantis is an insect-eating insect. It is about three inches long. The front legs are often held in a position suggesting prayer. However, this is just the mantis' method of being ready to catch a grasshopper or other insect that may come along. The praying mantis is common in many gardens. Look for one in your garden. (Hugh M. Halliday photo)

**Scientists also help in other ways**

As you have learned, scientists have done wonders in developing effective insecticides to control harmful insects. However, sometimes sprays and dusts are of no value. In such cases, the scientist tries to produce a *resistant variety* of crop. An example of an insect controlled in this way is the *sawfly* of the prairies. The sawfly larva damages wheat crops by boring downward *inside* the wheat stem through the joints, finally cutting off the stem. It could not be reached by poisons. So the plant scientists developed two varieties of wheat, Rescue and Chinook, which have solid stems instead of the usual hollow stems. The sawfly larva cannot damage solid-stemmed varieties.



This is a tomato hornworm caterpillar in which a small parasitic wasp has laid its eggs. The wasp larvae feed inside the caterpillar. When full-grown, they form many small, white cocoons which are attached to the outer skin of the hornworm caterpillar, as in this photograph. If you find such a caterpillar, do not destroy it. The wasp pupae will develop into adult wasps to lay more eggs in more hornworm caterpillars, thereby weakening and destroying them. The tomato hornworm is a garden pest in southern Quebec and Ontario. (Hugh M. Halliday photo)

The work of finding new methods of control must go on continually. Sometimes a new spray, such as DDT, is effective for a time. Then some insects develop a resistance and are not harmed. When this happens, new insecticides must be developed and used.

**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

1. Outline the life-history of the cutworm, mentioning egg, larva, pupa, and adult stages. In which stage is the insect harmful?

2. Why is the life-history of the cutworm referred to as a complete metamorphosis, while the grasshopper is said to pass through an incomplete metamorphosis?

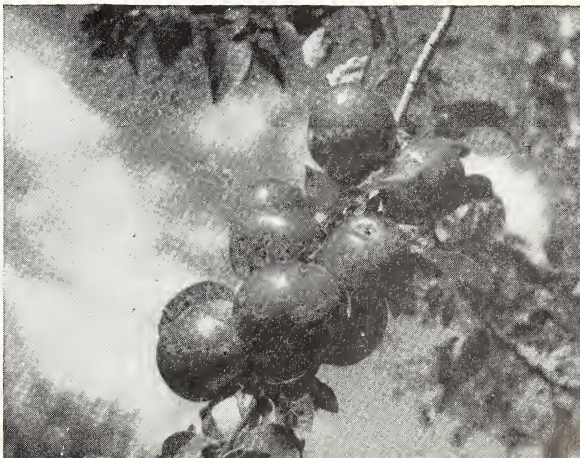
3. Discuss the problem of the control of cutworms under the following headings: (1) by methods of cultivation, (2) by poison baits, (3) by sprays. Which of the methods you suggest are effective against cutworms in gardens and which against cutworms in fields?

4. Name one other insect that is injurious to our crops. Outline its life-history. In what stage or stages is it harmful? How can it be controlled?

5. How are sucking insects controlled? Why are poison baits of no value in checking these insects?

6. Select one insect that seriously damages plants from which we secure materials for clothing or shelter. Give some important facts about the insect and the methods of controlling it.

7. As you have learned, scientists, by studying the habits of parasitic insects, have shown us how to use certain of them to protect our crops from harmful insects. Discuss the value of this contribution of science to the gardener, the fruit-grower, and the farmer, and in the conservation of our forests.



From the time the tree is planted until the fruit matures, a fruit-grower must make constant use of the findings of scientists if he wishes to harvest luscious fruit like that shown here. Make a list of some ways in which science should be applied in growing apples and other kinds of fruit. (Canadian Industries, Ltd. photo)

## WEEDS

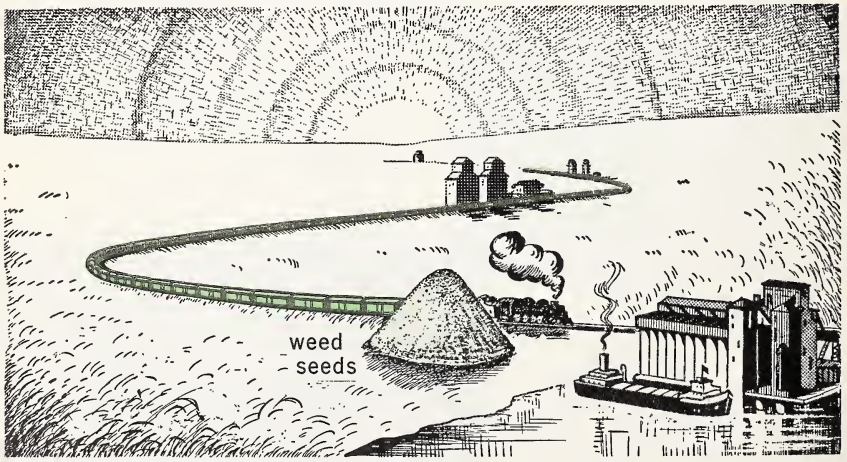
Weeds are plants growing in the wrong place – plants that we do not want, but that sometimes continue to grow in spite of all we can do to get rid of them. They present to farmers and gardeners one of their greatest problems. If weeds are not held in check, fine crops cannot be grown; farms cannot be operated profitably; nor can shrubs, flowers, and lawns be produced to beautify our homes.

### How much do weeds cost us?

Weeds decrease yields by robbing crops of plant food material, light, and moisture. They crowd out useful but less hardy plants. Wild oats and mustard lower the grade and increase the dockage in grain crops; burrs reduce the value of wool; stinkweed spoils the flavor of milk. When weeds infest our fields and gardens, it costs money to get rid of them. Furthermore, it is estimated that over $500,000.00 is spent annually for freight on weed seeds shipped in wheat and other grains from farms in Saskatchewan to the terminal elevators at Fort William and Vancouver. It has been reported that "weeds cause the farmer greater losses than do insects and plant diseases combined."

### Noxious weeds

Certain weeds cause so much damage or are so difficult to get rid of




It has been estimated that in one year over 14,000,000 bushels of weed seeds were mixed in with the grain shipped out of Western Canada. The freight cost of transporting this great quantity of weed seeds would be close to $1,000,000.00. If each railway car holds 2000 bushels, how many trains of 55 cars each would be required?

that they are classed as *noxious weeds* and are named in the *Weeds Act* in each province.

Many noxious weeds are adapted to live in various climates and types of soil, and are therefore widespread. For example, the following weeds are listed in both the *Noxious Weeds Act of Alberta* and in the *Weed Control Act of Ontario:*

| | | |
|---|---|---|
| perennial sowthistle | white cockle | ragweed |
| Canada thistle | members of the | bladder campion |
| stinkweed | mustard family | field bindweed |
| Russian thistle | | common barberry |

Other weeds grow in more restricted areas. The following lists indicate that some are serious pests in one province but not in another.

| *Alberta Noxious Weeds Act* | | *Ontario Weed Control Act* | |
|---|---|---|---|
| hoary cress | Russian knapweed | bedstraw | dodder |
| leafy spurge | Russian pigweed | blue-weed | goat's beard |
| wild oats | blue burr | burdock | goldenrod |
| hemp | tumble weed | chicory | hawkweed |
| toadflax | black-headed sunflower | cinquefoil | knapweed |
| blue lettuce | corn spurry | buckthorn | milkweed |
| false flax | couch grass | St. John's wort | ox-eye daisy |
| shepherd's purse | hedge bindweed | dock | pepper grass |
| red root | tartary buckwheat | spurge | poison ivy |
| hemp nettle | downy brome grass | white cockle | wild carrot |
| cow cockle | | yellow rocket | wild lettuce |

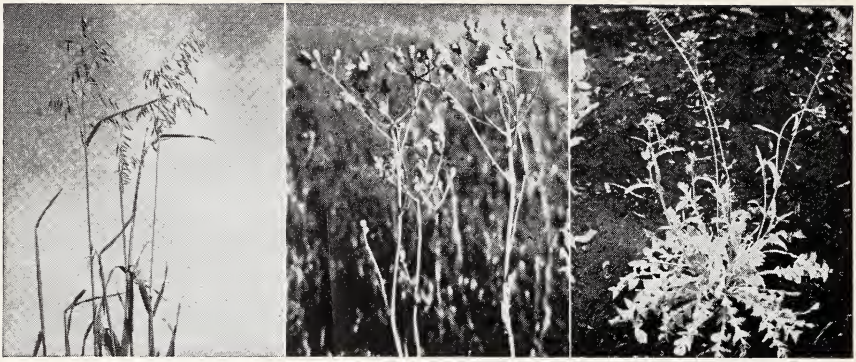
Everyone who wishes to grow crops should be familiar with the noxious weeds and with the methods of controlling them.

### Classes of weeds

Weeds are classified according to their length of life. *Annuals* grow, flower, and produce seed, and die in one year. They are reproduced from seed. *Winter annuals* are annual weeds that begin to grow in the fall and survive the winter. Such weeds, you will readily see, have a great advantage over the crops that are not planted until the following spring. *Biennials* are two-year plants. They store up food, usually in the root, the first year. The second season they produce seed. *Perennials* live for more than two years. They are reproduced by rootstocks or underground stems as well as by seeds.

### How to know weeds

The best way to learn to recognize weeds is to go out to where they are growing, and study the weeds themselves.



Wild Oats | Perennial Sow Thistle | Shepherd's Purse

White Cockle | Stinkweed | Hoary Cress

Bladder Campion | Toadflax | Canada Thistle

Some common weeds. Which of these are listed among the noxious weeds in the Weeds Act of your province?

All the photographic illustrations of weeds in this chapter were reproduced through the courtesy of the Line Elevators Farm Service, Winnipeg, Manitoba.

Wild Mustard

Field Bindweed

Leafy Spurge

A very good method of becoming acquainted with weeds is to learn their general characteristics by families. The members of each family have many distinguishing marks in common, and once the identity of an unknown weed has been traced to the proper family, complete identification is much easier. The descriptions given here will be useful for reference.

#### SOMETHING TO DO

The following plant families include many noxious weeds. Select two that include weeds common in your locality, and make a special study of them. In each case collect a good specimen of the weed described and a few others in the same family. Compare your first specimen with the description. Examine the other weeds to find their common characteristics and other facts about them.

1. The Mustard or Cress Family. — All the plants in this family have cross-shaped flowers with four petals. Seeds are produced in pods.

*Stinkweed.* — Annual or winter annual, reproduced by seeds. Root — fibrous. Stem — from two to twenty-four inches high. Leaf — wavy edge; upper leaves clasp stem with arrow-shaped base. Flower — small, white, four petals, in clusters that bloom and produce seed from early spring to late fall. Seed — small, purple with a metallic appearance, ringed, borne in pods that are winged with a notch at the top.

*Other weeds of the Mustard family.* — Wild mustard, tumbling mustard, hare's ear mustard, ball mustard, pepper grass, bird rape, false flax, hoary cress.

2. The Thistle or Daisy Family. — The flowers are produced in heads or compact clusters. The head of a sunflower or a thistle is a good example. Each part of the head is a little flower or floret. Many seeds have feathery parachutes.

*Perennial sow thistle.* — Perennial, reproduced by seeds and running underground stems or rootstocks. Stem — from

one to five feet tall, hollow, filled with bitter milky juice. Leaf — long, deeply cut, with points turning slightly backward, filled with bitter milky juice; clasps stem with arrow-shaped base. Flower — large, bright-yellow, composed of florets, in large clusters. Seed — small, reddish-brown, ribbed lengthwise and cross-wrinkled, topped with a parachute of fine hairs.

*Other weeds of the Thistle family.* — Canada thistle, annual sow thistle, dandelion, ragweeds, burdock, knapweed, goat's beard, wild lettuce, hawkweed, goldenrod, chicory, ox-eye daisy.

3. The Grass Family. — These plants have long, narrow leaves and jointed stems. Good examples are grains and common grasses.

*Wild oats.* — Annual, reproduced by seeds. Root, stem, and leaf closely resemble cultivated oats. Seeds — more slender than cultivated oats, white, black, grey, and brown; have horseshoe-shaped mouth, surrounded by stiff bristles, and a twisted awn bent at right angles.

*Other weeds of the Grass family.* — Couch grass, darnel, foxtail, crab grass.

4. The Pigweed Family. — These plants have small, inconspicuous, greenish flowers and seeds wrapped in papery covers.

*Russian thistle.* — Not a thistle. Annual, reproduced by seeds. Root — small, tap, easily broken off when ripe in the fall. Stem — dark green when young, striped with red as it ripens. Leaf — long, needle-shaped, pointed; drops off soon after seed is produced. Flowers — small, greenish. Seed — small, 50,000 to a plant, olive green, cone-shaped, coiled like a snail shell, papery covering. A very bad tumble weed.

*Other weeds of the Pigweed family.* — Lamb's quarters and Russian pigweed. Red-root pigweed does not belong to this family, but to one closely related.

5. The Pink Family. — The stems of the plants are usually swollen at the joints. The parts of the flowers are usually in fives, occasionally in fours. Petals are sometimes missing. The seeds are in one- to five-celled pods and attached to a column in the centre of the flower.

*The purple cockle.* — Annual and winter annual. Root — fibrous. Stem — from two to three feet tall; few branches. Leaves — long, narrow, pointed; whole plant covered with fine silky hairs. Flowers — large, purple, borne singly at tips of branches. Seeds — large, black, rounded triangular in shape, rough; in large pods with five teeth at top.

*Other weeds of the Pink family.* — Cow cockle, night-flowering catchfly, bladder campion, white cockle.

## Poison Ivy

*Know it! Avoid it! Destroy it!* Why should a plant have such a label as this? Perhaps you know that if you come in contact with any part of poison ivy that may be crushed, it causes your skin to itch. Later, blisters and sores develop. It may even make you quite ill.

Poison ivy grows in all provinces in Canada, and especially in Ontario and Western Quebec. It is classed as a noxious weed in Ontario.

*How can you know poison ivy?* Examine carefully the illustrations on the next page. Notice: (1) The *three-parted leaves.* They may vary in shape. They may be reddish-colored

Beware of poison ivy! Watch for three leaflets and small white fruit. (H. H. Harrison photo)

in spring, green in summer, and orange, red, brown, or yellow in fall. But — *watch for the leaf with three leaflets.* (2) The *small, white fruit.* The small, whitish flowers of the poison ivy produce these fruits which are at first greenish-yellow, then waxy-white.

*What to do about poison ivy: Treatment.* — (1) Thoroughly wash your clothes and all parts of the body that have been in contact with the plant, with good laundry soap and water. (2) If sores or itching develop, apply calamine or other lotion made for this purpose. (3) In severe cases, a doctor should be consulted. *Eradication.* — The methods of *cultivation, spraying,* and above all *co-operation,* recommended on the following pages, are effective.

#### SOMETHING TO DO

1. Make a study of the weeds common in your locality. Collect a representative specimen of each weed, and press and mount it. Classify the weeds in your collection as annuals, winter annuals, biennials, and perennials.

2. Make a collection of weed seeds. Place the seeds in small bottles, and mount the bottles on cardboard. The names of the seeds may be pasted on the bottles or printed on the cardboard below each bottle.

3. Try to recognize the weeds you have studied when you see them in

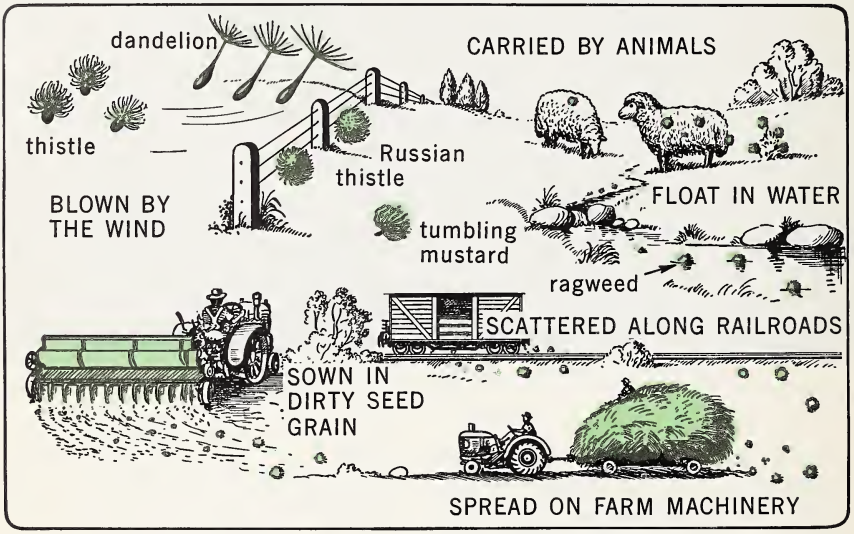
fields and in gardens or along the roadside.

4. Arrange a field trip for the purpose of studying weeds. Try to enlist the assistance of someone who is familiar with a number of common weeds.

5. Make a study of the various ways in which weeds are scattered. Prepare a chart to illustrate these different methods.

6. Draw charts to show weed damage.

7. Plant a number of seeds of different noxious weeds in a box or in a plot outside. Watch for the young plants, and learn to recognize them in their earliest stages.




Some ways in which weeds are scattered. What other ways do you know?

**TEST YOUR KNOWLEDGE AND UNDERSTANDING**

1. What is a noxious weed?
2. Name ten noxious weeds common in your district.
3. Gather specimens of all the noxious weeds you can find in and about your school yard. Group them in their respective plant families.
4. Describe the injurious effects of weeds.
5. Mention two distinguishing characteristics of two plant families you have studied.
6. How can we recognize poison ivy? What treatment should be given to relieve poison ivy sores and itching?

*Try this test.* — A practical test on weeds will be interesting and helpful. Have on hand specimens of the plants and seeds of common weeds. Pupils and teacher can work as a team to collect specimens and to plan the test. Try to identify both the weeds and their seeds. Make it a game or a contest. Do not let it become a burden. You will do well to learn to recognize eight or ten new weeds in a year.

Afterward, look for the same weeds outdoors.

## FIGHTING WEEDS

When the pupils in Miss Peterson's class learned of the great waste and loss caused by weeds, they became interested in finding out whether or not much or all of it could be prevented.

They organized committees to visit farms and to secure information in other ways.

Elaine Scott and Charlie Hunt were especially disturbed when they learned that some farmers actually sow quantities of noxious weed seeds with the seeds of their grain crops. So they made a study of methods of preventing the spread of weeds, and reported as follows:

"In the war against weeds," emphasized Elaine, "an ounce of prevention is worth very much more than a pound of cure. To stop the spread of these harmful plants, a number of precautions should be taken. (1) Farm machinery should be well cleaned before being moved from one place to another. (2) Weeds along roadsides and fences should be prevented from producing seeds to get into surrounding fields. (3) Only good and well-cleaned seed should be sown. (See page 321 for a brief description of a fanning mill used to clean seed grain.) (4) Manure containing weed seeds should not be spread on fields until it is well rotted. When manure is thoroughly rotted, the germinating power of weed seeds in it is destroyed."

"And furthermore," said Charlie, "the prevention and control of weeds is a community concern. One person can do little by himself. How can your neighbor keep his fields free from weeds if your fields are full of weeds producing seeds to be spread far and wide? How can one person have a clean lawn, if the lawn next door or the vacant lot across the street is infested with dandelions or other weeds? *Only by the co-operation of every person in the locality can weeds be successfully held in check.*" In concluding his report, Charlie asked, "Are *you* doing everything you can do to prevent the spread of these wasteful plants?"

**All weeds cannot be controlled by the same methods**

Annuals must be attacked in one way and perennials in another. Why? Annuals are reproduced by seeds. The full-grown plants soon die, but the seeds may remain alive in the ground for many years. Therefore, if we wish to control annuals, we must do two things: (1) see that the seeds in the soil grow into plants at a time when it is possible to destroy them, and (2) prevent plants from producing more ripe seeds.

Perennials are reproduced by rootstocks or underground stems as well as by seeds, and the parent plants do not die in a year. In controlling perennials, therefore, it is the plants themselves and the rootstocks that we must attack and kill. Of course, if there are seeds of perennials in the soil, they must be made to germinate in order that they may be destroyed.

### How to attack annuals

Malcolm Gray and Oliver Sereda reported regarding the control of annual weeds. "Remember," said Oliver, "that in dealing with annuals, it is the seed that must be attacked."

Malcolm then outlined these methods:

1. As many weeds as possible should be killed before the crop is sown. Fall and spring cultivation to germinate seeds and destroy plants is an effective way of ridding the soil of many weeds and weed seeds.

2. Cultivating the summerfallow at intervals will permit weed seeds to germinate, and will destroy weeds before more seeds are produced. This cultivation should be done only often enough to control weeds. Too much cultivation may lead to serious wind or water erosion.

3. Sowing the land down to grass or legumes for a few years will keep weeds in check.

4. Using fertilizers will help crops to grow rapidly and keep ahead of the weeds.

5. Many annuals may be destroyed by spraying them with chemicals such as 2,4-D.

| Plants That Are Reproduced by Seeds Produce Great Quantities of Seed | |
|---|---|
| One Tumbling Mustard plant produces | 1,000,000 seeds |
| One Lamb's Quarters plant produces | 50,000 seeds |
| One Frenchweed plant produces | 18,000 seeds |
| One Russian Thistle plant produces | 50,000 seeds |

### How to deal with perennials

Fay Stodalka and Walter Forbes prepared the report on perennials. They learned that such weeds as perennial sowthistle and Canada thistle must be fought to the finish.

Fay reported, "It is often necessary to summerfallow a field to destroy perennials. The soil must be kept black, allowing no leaves to appear. This has the effect of both starving and smothering the plants." In their remarks, both Fay and Walter warned against cultivating the soil to such an extent that soil erosion becomes a problem.

Walter said many farmers seeded fields infested with perennials down to a crop such as brome grass which smothers weeds effectively.

The report also included the use of chemicals to destroy perennial weeds.

NOTE. — Many of the publications of the provincial and federal Departments of Agriculture are excellent sources of information regarding plant enemies and other agricultural topics. Teachers should note, however, that these materials *are available to schools,* and *not to pupils,* and *when requested for school purposes should become school library property and be preserved for use with successive classes.*

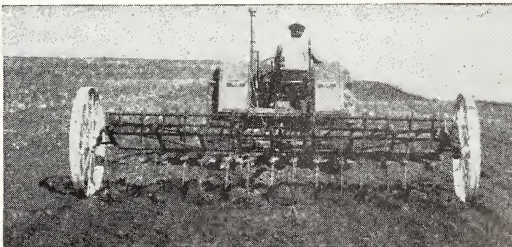
*Examples:*

In Saskatchewan, an extremely useful publication, *Guide to Farm Practice in Saskatchewan,* can be secured free of charge upon application to the Agricultural Extension Department, University of Saskatchewan, Saskatoon. It is a 200-page booklet containing valuable information regarding soil zones, cereal crops, forage crops, cropping systems, weed control, insect pest control, horticulture, soils, agricultural engineering, livestock, poultry, and dairying. It is revised and reprinted periodically.

In Alberta, various publications are available, but they are not distributed directly to schools or pupils. A kit has been assembled by the Department of Education and is available, without charge, to schools. Teachers should send requests to the Curriculum Branch, Department of Education, Edmonton.

Teachers should also use the *List of Available Publications,* Information Service, Department of Agriculture, Ottawa, for the purpose of selecting useful publications. From this source, too, teachers should be careful to *select only single copies of publications really needed and should be sure to place them in the school library for future school use.*

Cultivating the soil, before the crop is sown and in some cases afterward, is an effective method of weed control. However, it is important to use the right implement in the right way. How are the implements shown below useful in controlling weeds? What other implements are also employed? (Department of Agriculture photo)



Spraying with 2, 4-D is an effective method of destroying weeds in growing grain crops. Top: Tractor-drawn spraying equipment. Centre: Spraying a field by means of an airplane. Lower: 2, 4-D does kill weeds; the field at the right was sprayed, the field at the left was not sprayed. (Regina Experimental Station and Aviation Services photos)

### Chemical control of weeds

A special report on chemical weed-killers, or *herbicides*, was undertaken by Tom Grant and Gary Morin. In his report Tom said, "We have learned that bad weeds interfere with the production of our food supply. Scientists have greatly helped the farmer and gardener by developing chemicals to control weeds. The wise farmer and gardener keep up to date on the study of weed control."

Gary then reported, "Many broad-leaved weeds, such as wild mustard, can be controlled by spraying them with a chemical called 2,4-D. Crops must be treated at the right time or they may be injured. Another chemical, M.C.P., may be used to kill weeds in crops that might be damaged by 2, 4-D. New chemicals are continually being developed."

"In cities," continued Tom, "2,4-D may be purchased in stores and used on lawns to kill such weeds as dandelions and plantain."

In concluding this important report, Gary said, "Patches of deep-rooted perennials that are hard to destroy, such as leafy spurge, hoary cress, and Russian knapweed may be killed by using a chemical which controls all vegetation. However, it sterilizes the soil so that no plants will grow for several years."

It is evident that farmers must not only be able to identify troublesome weeds, but must also know which chemical is most effective against each kind of weed.

#### SOMETHING TO DO

Mark off a suitable weedy area in the school yard or on a lawn. Spray with 2,4-D, *being sure to follow the directions* on the container. What do you observe? What is your conclusion?

Test your knowledge. How many examples of the ways in which weed and other kinds of seeds are scattered can you find in this illustration? In what other ways may weed seeds be spread?

## The Weeds Act

Each province has its *Weeds Act.* This Act (1) lists the noxious weeds; (2) states that it shall be the duty of every owner or occupant of land to destroy noxious weeds on it; (3) sets forth the conditions respecting the appointment of weed inspectors; (4) defines the duties of the inspectors; (5) requires that machines used for threshing or cleaning seed must be thoroughly cleaned; (6) declares it to be unlawful to leave noxious weed seeds exposed where they can spread or grow; (7) provides penalties for inspectors who neglect their duties, and for persons who obstruct the inspectors or fail to carry out their orders.

### SOMETHING TO DO

1. Discuss weed control methods with the farmers in your district.
2. Consult weed bulletins to learn about recommended control methods.
3. Watch newspapers and magazines for reports on conventions or meetings held to discuss weed control. Watch also for hints about successful methods. Cut out worthwhile notices, and post them on the bulletin board at school.
4. Do all you can to help to keep your school grounds and the adjacent roadsides as free from weeds as possible.
5. Collect pictures and make drawings to illustrate the various methods of controlling weeds.
6. Who is responsible for the destruction of roadside weeds? Send to your provincial Department of Agriculture for a copy of the Weeds Act. It is free.

### TEST YOUR KNOWLEDGE AND UNDERSTANDING

1. State the family and one characteristic of each of *five* noxious weeds.
2. How can farmers prevent weeds? Explain the importance of co-operation.
3. In controlling annuals, is it the seed or the plant that must be attacked? Why?

4. Briefly outline suitable methods for controlling (1) stinkweed, (2) perennial sow thistle or Canada thistle.

5. Show how science has helped to control weeds by developing chemical weed-killers or herbicides.

6. Summarize important sections of the Noxious Weeds Act.

## WHAT HAVE YOU LEARNED?

### IMPORTANT IDEAS AND UNDERSTANDINGS

A

1. The production of farm, garden, and forest crops, that provide us with materials for food, clothing, and shelter, is greatly hindered by noxious weeds, plant diseases, and insect pests.

2. Many widespread and harmful plant diseases are caused by parasitic plants called fungi.

3. There are two general classes of injurious insects: those with biting mouthparts, and those with mouthparts fitted for sucking.

4. While plant diseases and insect pests annually cause serious damage, weeds are responsible for even greater losses and expense.

5. Scientists have contributed greatly to the fight against plant diseases, harmful insects, and noxious weeds.

6. The effective control of weeds, disease, and insects must be a co-operative undertaking. One farmer or gardener can do little by himself.

(a) The foregoing sentences are all true statements of important science ideas and understandings. Read and discuss them carefully as a review of this chapter.

(b) The following sentences describe situations in which some of these ideas apply. To test your ability to apply ideas to actual situations, match sentences in A with sentences in B to which they apply.

B

1. While on a science discovery trip, Ronald Shaw and Ralph Flaman found a currant bush that was badly injured. No leaves had been eaten, but many were curled up to form little balls containing numerous tiny insects.

2. Mr. Watson always had a good garden. No weed was allowed to grow. However, a neighbor permitted sowthistle to

flourish in his garden. The seeds blew over into Mr. Watson's soil. As a result, he was put to considerable trouble each spring to destroy the numerous young sowthistle plants that started to grow.

3. A farmer delivered 1500 bushels of wheat to a grain elevator. It was found that weed seeds in the wheat amounted to 4 per cent of the total weight. The grain, therefore, was "docked" 60 bushels, and the farmer was credited with only 1440 bushels.

4. A group of pupils decided to make a survey of the diseases, insects, and weeds causing damage to crops in their neighborhood. They found several kinds of rust, smut, root-rot, and wilt, and insects such as the wireworm, cutworm, and grasshopper in grains and other field crops; and in gardens they discovered wilt, blight, scab, and other diseases, as well as aphids, cutworms, potato and other beetles, cabbage worms, and other injurious insects. Their list of weeds was too long to mention here.

**IMPORTANT SCIENCE TERMS**

A

| | | |
|---|---|---|
| control | laboratory | insecticide |
| fungus | resistant variety | parasite |
| spore | metamorphosis | noxious weed |
| fungicide | pupa | biennial |
| 15B rust | larva | rootstock |
| seed treatment | nymph | 2,4-D |

To show that you understand and can use the science terms listed in A, match with the situations described in B those terms which apply.

B

1. A farmer seeded Thatcher wheat in one field and Selkirk wheat in another. During the summer, the Thatcher became badly rusted, but the Selkirk remained clean and golden. The seed for both fields had been prepared in exactly the same way.

2. Ruth Osmak's father had an excellent lawn until hundreds of dandelion seeds blew in from a vacant lot across the street. Mr. Osmak tried to dig out each young dandelion plant as soon as it appeared. Then he learned of a chemical spray that killed the dandelions. When Mr. Osmak applied this chemical to his lawn, the dandelions soon disappeared.

3. One fall, Jack and Edith Hopkins found a brown, papery cocoon wrapped up in a leaf. They learned that it had been made

by a Cecropia caterpillar. They put the cocoon away in a cool place. In spring, an adult Cecropia moth emerged.

4. It was recently stated that without the chemical sprays and dusts available at present to control insects, the fruit-growing industry could not survive. Some years ago in the United States, the codling moth destroyed almost one-half of the apple crop.

5. Roger Forbes was visiting Gordon Wayne at his home on the farm. The two boys watched the rust disease developing in the fields of wheat. First a few plants were infected, then more and more, as the disease spread from plant to plant.

### SCIENTIFIC METHOD AND ATTITUDES

1. A farmer discovered that weeds threatened to seriously reduce the yield in a field of grain. He was not able to recognize or name them. However, he decided to spray the crop to remove the weeds in it.

Review the steps of the scientific method outlined on pages 28 to 35.

In which of the two cases below did the farmer follow the scientific method? In each case, tell in your answer which steps of the scientific method were followed and which were not followed.

(*a*) He remembered that he had some spray chemical left over from the previous year and used it to spray his weedy crop.

(*b*) He communicated with the agricultural representative in his locality to find out what the weeds were and what spray was recommended to control them.

2. When the scientists in the Dominion Entomological Laboratory at Belleville, Ontario, began their work, there were people who said that it was unwise to distribute parasitic insects, that instead of helping to control injurious pests, the parasitic insects might well become harmful and difficult to control. However, the Laboratory has been in operation thirty years and has distributed millions of parasites with only good results.

(*a*) Will the people who considered it unwise to distribute parasitic insects be right in continuing to hold to their first opinion regarding the Laboratory? Give a reason for your answer.

(*b*) Which of the scientific attitudes discussed on pages 12 to 15 must be considered in your answer?

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